Science and Technology Project in Mission Mechanism

Integrated Vector Control of Malaria, Filaria and other Vector Borne Diseases

ANNUAL REPORT 2000

MALARIA RESEARCH CENTRE
(Indian Council of Medical Research)
22 - Sham Nath Marg , Delhi - 110054

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AN OVERVIEW OF THE ACTIVITES

The Science and Technology Project on the Integrated Disease Vector Control of Malaria, Filaria and other Vector Borne Diseases is being carried-out through our field stations in different parts of the country. Keeping in view the new mandate given to each field station by the Exective Committee of the Project in June, 1999 activities at the field stations were directed accordingly.

Collaboration with health authorities like with Ahmedabad Municipal Corporation by Nadiad field station, Mormugao Port Trust Area authorities by Goa field station, Municipal Corporation in Bangalore and State malaria control programme in District Hasan by the Bangalore field station, and NTPC's by Hardwar field station in preparing malaria/mosquito control action plans, and provinding technical know-how and facilitating transfer of technology for malaria control were fruitful. In these areas, bioenvironmental control strategy was found suitable to reduce the vector population and to contain the desease prevalence. Also surveys were conducted in outbreak areas like Betul, Hoshangabad and Chhindwara in Madhya Pradesh, a few tea gardens and other areas in Assam, Moradabad in U.P., C.N. Halli taluka of Tumkur district by the field stations to provide help in detecting the cases, to provide treatment at the earliest and to investigate the epidemics to identify the factors responsible. In many of these areas, studies were taken on the request of the concerned agencies. Many field stations participated in the trials to evaluate new drugs, insecticides and diagnostic kits. These activities justify the basis with which these field stations were established.

To keep up with the spirit of malaria month (June 2000) all the field stations planned activities involving communities to enhance the awareness of malaria and the control strategy being implemented in the national programme. In addition to applied and operational activities related directly to the control programme, at many field stations basic research to isolate new molecules/agents for mosquito or parasite control were carried out. For the first time a study has been initiated in Sundergarh district of Orissa to develop a field stite for vaccine trials. Sonapur, Goa, Bangalore and Rourkela field stations participated in situational analysis at five pilot districts namely, Jodhpur in Rajasthan, Aizwal in Mizoram, Tumkur in Karnataka, Keonjhar in Orissa and the entire state of Goa under Roll Back Malaria (RBM) initiative.

Training of health personnel in microscopy, promotion of technolgy and use of insecticide treated mosquito nets through awareness camps, lectures, demonstrations and motivating patients attending the malaria clinics, and organization of intersectoral workshops were important activities at many of the field stations.

Inspite of several practical and logistic problems the field stations are facing, the scientists and the supporting staff carried-out the work with full enthusiasm and commitment.

DIRECTOR

GENERAL PROJECT INFORMATION

1. **PROJECT TITLE:** Science and Technology Project on the Integrated Vector Control of Malaria, Filaria and Other Vector-borne Diseases.

2. **OVERALL OBJECTIVES**

(i) Integrated vector control of malaria and other vector-borne diseases in different agro-climatic regions of the country under the influence of different vector species/parasites and other socio-economic problems.

(ii) Development of cost-effective model for extension and/or duplication in similar geographical areas of the country.

Additional Objectives (Starting March 1989)

(i) District level implementation of the bioenvironmental control of malaria strategy in Gujarat and U.P. through the district infrastructure and primary health care system using existing resources and man power.

(ii) Preparation of mosquito control action plan for the entire metropolis of Delhi (State) and Chennai (T.N.).

(iii) Preparation of training manuals, video films and organization of training programmes for various categories of medical and para-medical officers, technicians, engineers, architects and officers of other collaborating agencies.

(iv) Basic and applied research to support field activities.

3. **NODAL DEPARTMENT WITH COLLABORATING AGENCIES**

Nodal Department : Indian Council of Medical Research
Institute : Malaria Research Centre

Collaborating Agencies

(i) National Anti Malaria Programme (NAMP),

(ii) State Health Departments and Corporations/Municipalities, and

(iii) Local Institutions and other State and Central Government Departments.

4. BUDGET

STP (IDVC) for the year 2000-2001

(i)	Grant-in-aid received from	in Rupees
	Opening balance as on 1-4-2000	5,56,934.27
	ICMR	1,54,43,065.00
	Ministry of Health & Family Welfare	1,50,00,000.00
	Grand Total	3,09,99,999.27

(ii)	Actual expenditure for the year	in Rupees
	Pay and allowances	2,70,11,448.00
	TA/DA	4,95,294.00
	Contingent consumable	34,83,977.00
	Equipments	7300.00
	Closing balance on 31-3-2001	1980.27
	Grand Total	3,09,99,999.27

5. HIGHLIGHTS OF RESEARCH ACTIVITIES

Nadiad (Gujarat): Urban malaria problem in Ahmedabad City was studied in-depth and bioenvironmental control was demonstrated. A malaria action plan is now being prepared, which is nearing completion. A study on malaria in Surat City with DFID assistance is in advanced phase and on completion would help rationalise antimalaria activities. Two new insecticides were tested in the field for malaria vector control in triple-resistance area in collaboration with WHO pesticide evaluation scheme. Rapid diagnostic kits Paracheck and OptiMAL were evaluated in the field. Several training courses and inter-sectoral coordination workshops were organized in different parts of Gujarat. A manual on larvivorous fish has been prepared.

Jabalpur (Madhya Pradesh): Epidemic investigations were carried out in Hoshangabad and Betul districts under EMCP on the request of the Government of M.P. Follow-up investigations in malaria outbreak affected villages of Narayanganj (District Mandla) and Mohkhed (District Chhindwara) were carried out. A clinical trial of azithromycin vs. chloroquine was initiated. Malariometric stratification of tribal and forested district, Mandla was undertaken. Rapid diagnostic kits Determine™ for *P. falciparum* and OptiMAL for both *P. vivax* and *P. falciparum* were evaluated in the field.

Hardwar (Uttaranchal): HPLC method for the determination of chlorproguanil, dapsone and their metabolites in plasma to study the pharmacokinetic parameters after giving LAPDAP was developed. Different HPLC-purified compounds from *Andrographis paniculata* were isolated and sent to WHO for screening their activities against different parasites. Studies were started on the synthesis of primaquine analogue in collaboration with CDRI, Lucknow. Studies on *Lantana camera* revealed that some synergistic effect might play a major role for the repellent property of MRCHR-2(5). A malariometric survey was carried out in Laksar PHC, District Hardwar. Transfer of bioenvironmental control strategy was continued at NTPC, Rihand Nagar.

Sonapur (Assam): Major areas of work were monitoring of multi-drug resistant malaria, clinical trial of azithromycin for the treatment of *P. vivax,* field evaluation of rapid malaria diagnostic kit, and situation analysis in Aizawl district (Mizoram) under roll back malaria (RBM) initiative. Technology of insecticide treated nets was promoted through number of awareness camps, lectures, and field demonstrations. Work on cytogenetic identification of sibling species of *An. culicifacies* and *An. minimus* from Assam was initiated.

Chennai (Tamil Nadu): A study on bioecology of *An. stephensi* with particular reference to different ecological variants in and around Chennai was undertaken. Implication of rainwater harvesting on the mosquito breeding was carried out. Field evaluation on the efficacy of hilmilin, an IGR compound, on the immatures of rice field breeding mosquitoes was completed. Surveys of indigenous larvivorous fish fauna, larvivorosity tests, usage of bednets by the patients attending the malaria clinic, and health education and training programmes were carried out during the year.

Rourkela (Orissa): A longitudinal and cross-sectional parasitological and entomological studies were conducted to develop suitable sites for malaria vaccine trials. A collaborative study was

carried out to understand the malaria transmission dynamics and to characterize parasite population and immune responses in a tribal population. Insecticide susceptibility tests showed that *An. culicifacies* and *An. annularis* were resistant to DDT and susceptible to deltamethrin; and *An. fluviatilis* is susceptible to both. Studies on haemoglobinopathies in a tribal population revealed that 20.4 and 16.4 per cent population were having G-6-PD deficiency and sickle-cell respectively. Gametocytocidal effect of 80/53 compound in uncomplicated *P. falciparum* cases was evaluated. A study on disease burden and economic loss due to malaria was initiated. The work on roll back malaria (RBM) initiative in Keonjhar district was started.

Haldwani (Uttaranchal): A malariogenic stratification study was conducted in all the PHCs of Districts Nainital and Udham Singh Nagar. A retrospective epidemic investigation in the villages of Bhojpur PHC (District Moradabad) was carried out. Insecticide susceptibility test against *An. culicifacies* showed resistance to DDT and malathion and susceptibility to deltamethrin. Several health education activities were also organized during the anti-malaria month.

Car Nicobar (A&N Islands): Bioenvironmental control strategy is being promoted in Car Nicobar Island. New larvivorous fish hatcheries were established; fish were distributed in new areas. Work on the malaria transmission dynamics and the role of *An. sundaicus* in creek and non-creek areas showed good progress. A study on bioecology of *An. philippinensis* was commenced. The mosquito fauna of Great Nicobar, Hutbay and Teressa Islands were studied. A survey on filariasis was undertaken.

Panaji (Goa): A technology transfer project on bioenvironmental control of mosquitoes in Mormugao port trust area in Vasco da Gama showed significant progress in reducing mosquitogenic conditions. Bioassays of various fungal and bacterial isolates were carried out to find indigenous mosquito pathogenic fungal agents. Further work on resting behaviour and incrimination of *An. stephensi* in Goa was undertaken. A KABP survey on insecticide treated mosquito net was conducted. A situational analysis of five high-risk areas of Goa was initiated under RBM initiative.

Bangalore (Karnataka): The project on bioenvironmental control of malaria in PHC Kamasamudram in District Kolar has been concluded successfully. In PHC Banavara, District Hassan, malaria was under control after the release of *Gambusia* fish into the tanks. An entomological investigation of a malaria outbreak in C.N. Halli taluk of Tumkur district was carried out. Mosquito control in Bangalore City has been initiated in collaboration with Bangalore Mahanagar Palika.

Shahjahanpur (U.P.): Geographical reconnaissance of Shahjahanpur town was carried out. A malariogenic survey at the proposed site of Thermal Power Station, Roza was carried out. Sites were selected for the biocide trial proposed to next year. Filaria and malaria prevalence was monitored.

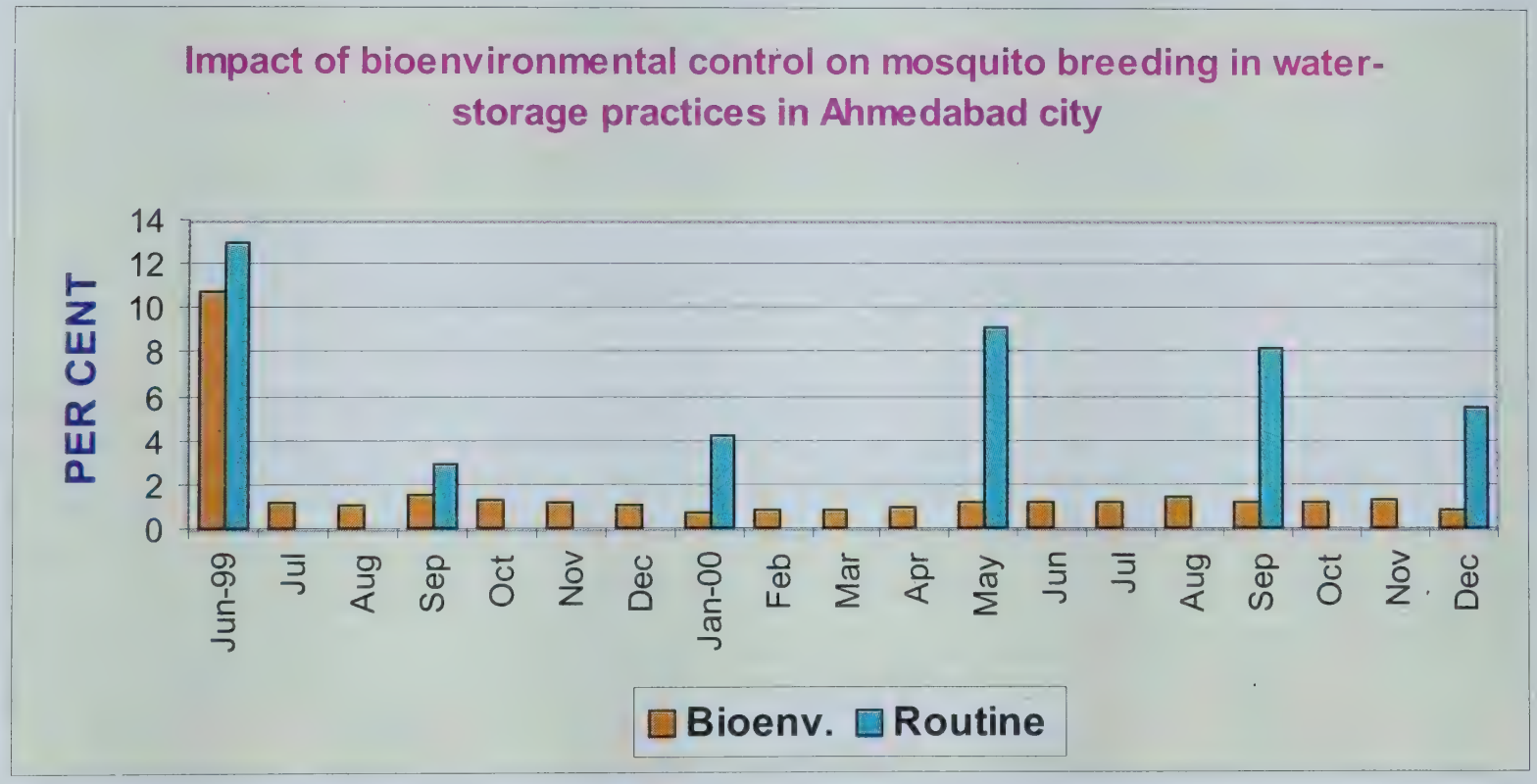
Shankargarh (U.P.): Malaria clinic was run as a passive surveillance agency to monitor disease prevalence in the area. Active surveillance for malaria was carried out in stone quarry areas. The drug resistance study in Daltonganj, District Palamu, Bihar reported chloroquine resistance in *P. falciparum*.

6. DETAILED PROGRESS OF THE WORK DONE

6.1 NADIAD (GUJARAT)

Demonstration of bioenvironmental control of urban malaria in Ahmedabad : A collaborative project with Ahmedabad Municipal Corporation (AMC)

A detailed epidemiological study on malaria and geographical reconnaissance of vector habitats in Ahmedabad was undertaken in 1996. From 1999, a project to demonstrate feasibility of control of urban malaria with biological control, environmental management, improved EDPT system and IEC was undertaken in two municipal wards. Several larvivorous fish hatcheries in available mill tanks, ornamental tanks were set up. For comparison, entomological monitoring and malaria surveillance was carried out in four wards in which malaria control activities were being carried out under the urban malaria scheme of the NAMP. To test sustainability, all activities were done through AMC staff except for entomological monitoring, examination of blood smears and support in IEC. During the year 2000, 248 group meetings and nine lecture demonstrations in schools were organised in wards with bioenvironmental control. Over 1,75,000 fish were released in different mosquito breeding habitats including water storage practices. A system to stock and distribute fish was developed by establishing small cemented tanks at several muster offices. Minor engineering works and source reduction activities like filling up of sluice valve chambers at pumping stations, repair of water leakages, cleaning of storm water drains, filling-up of puddles etc. were undertaken.



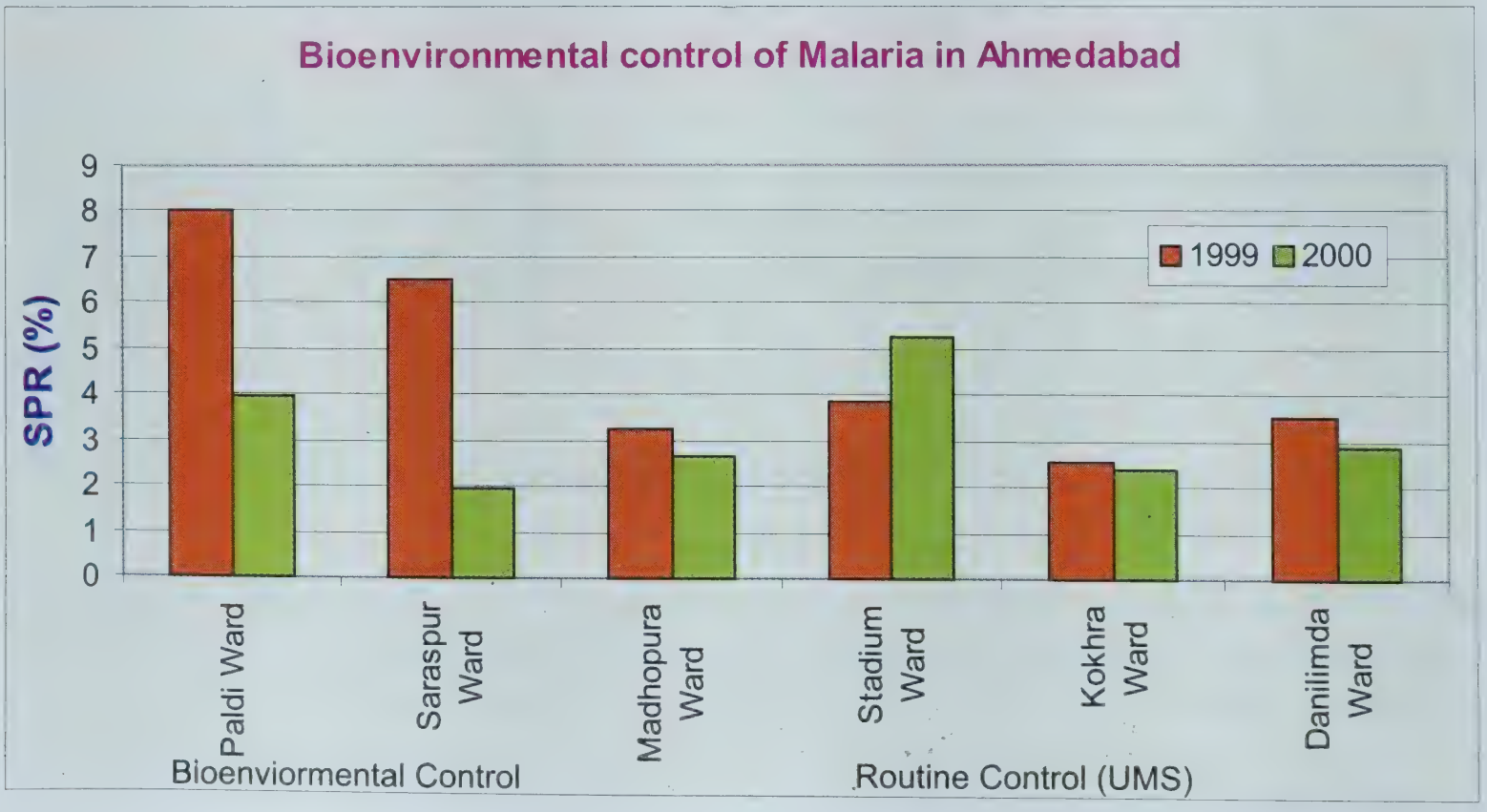
During the baseline period, indoor resting densities of *An. stephensi* and *Aedes aegypti* were compared in both the groups of wards. Following bioenvironmental activities, the densities were lower than in the routine wards under UMS, or at the most comparable in lean months. Periodic surveys of intradomestic water storage practices were also undertaken. In the baseline month, 10.8 per cent containers were positive with larval breeding in bioenvironmental wards compared 12.9 per cent in control wards. In

subsequent months, however, the container positivity rate ranged from 0.8 to 1.7 per cent in the former compared to 2.9 to 9.1 per cent in the latter, thereby showing considerable impact on the larval breeding. There was a significant impact on the malaria incidence as well. The slide positivity rate in bioenvironmental control wards declined from 8.02 per cent in 1999 to 3.95 per cent in 2000 in Paldi ward, and from 6.51 to 1.96 per cent in Saraspur ward. During the corresponding years, malaria in wards under routine control increased from 3.86 to 5.24 per cent in Stadium ward, whereas there was a marginal decline (Madhopura: 3.27 to 2.66 per cent; Kokhra: 2.57 to 2.38 per cent; Danilimda: 3.51 to 2.86 per cent). Thus in conclusion, bioenvironmental measures were either more or less as effective as the routine measures based on insecticidal control. It is proposed to organise a dissemination workshop during 2001 in collaboration with AMC by which time malaria action plan document would also be made ready.

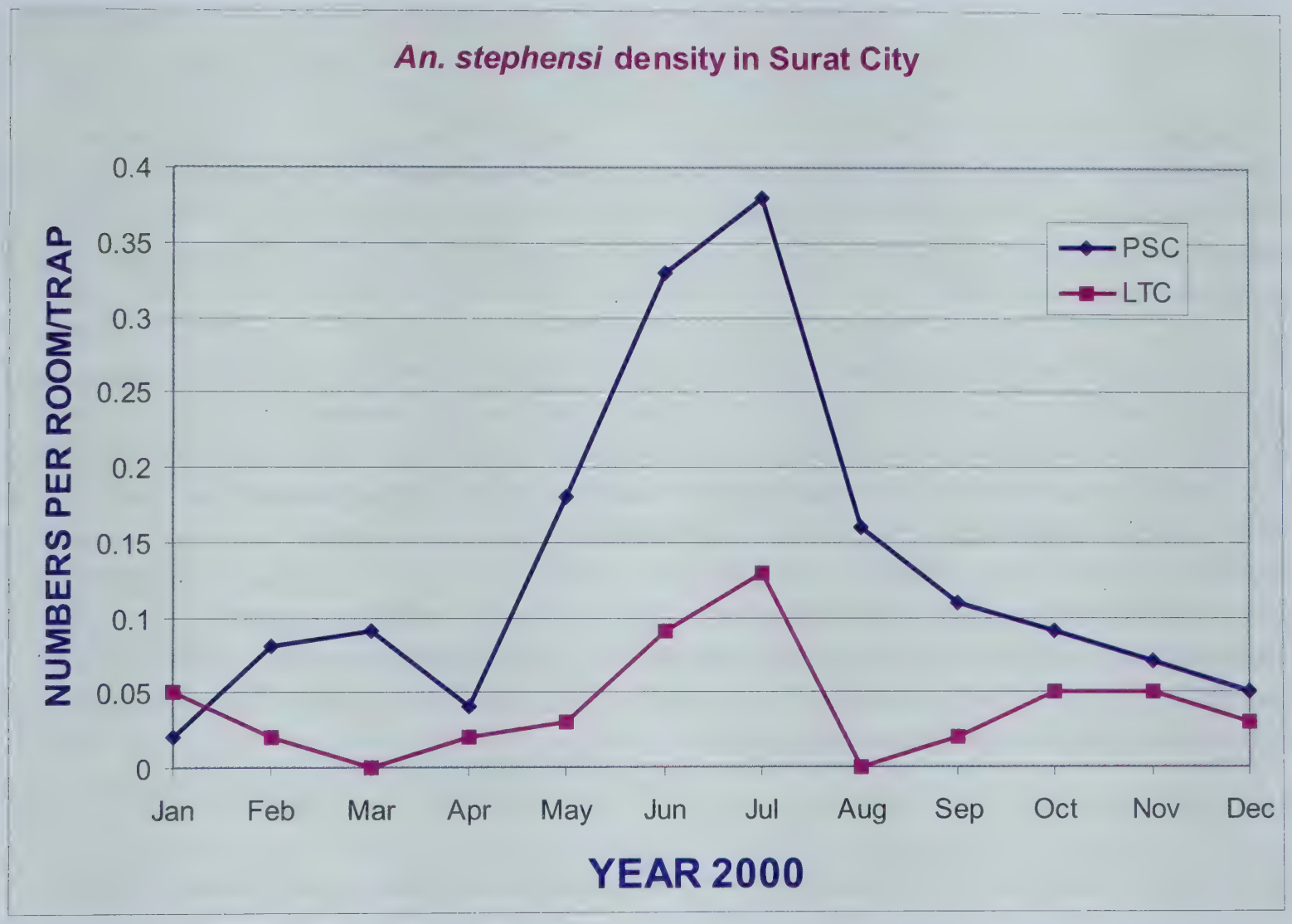
Vector bionomics and evaluation of the sensitivity of malaria parasites to antimalarials in Surat City

A collaborative Malaria Control and Research Project (MCRP) was launched in Surat with the assistance of Department for International Development, India (British High Commission) in 1996. The overall objective of the project is to develop alternative, cost-effective and sustainable method of malaria control in Surat district, which can also fit into the ongoing antimalaria programme. Urban malaria research is one of the important components of the MCRP. Malaria Research Centre field station (ICMR), Nadiad has been working on the epidemiology of malaria in close collaboration with the Ahmedabad Municipal Corporation since January 1996 with the ultimate goal of preparing a comprehensive malaria action plan for the city. Based on this experience, the MRC was identified to undertake Vector Bionomics Study (VBS) in Surat City in collaboration with the Surat Municipal Corporation.

The project on VBS was launched in June 1999 with the following major objectives to assist the development of an appropriate and efficient entomological monitoring unit within the Surat Municipal



Corporation (SMC) aiming at providing sustainable entomological support to the urban malaria control programme, to study the vector bionomics in Surat in order to understand the malaria transmission dynamics, to evaluate the vector susceptibility to the currently used insecticides and larvicides intended to rationalise their usage in the programme, to evaluate the sensitivity of *P. falciparum* and *P. vivax* to antimalarial drugs and to assess the need for engineering and environmental methods of vector control.



Setting up of entomological monitoring unit: A well-equipped entomological monitoring unit has been established in the premises of the Surat Municipal Corporation as a part of the project objectives. All necessary equipments, instruments and kits have been placed in this unit so as to make it a sustainable entomological monitoring unit for the SMC. The entomology staff of SMC was imparted training in various entomological techniques at MRC, Nadiad before the launch of the project. Under the supervision of a senior scientist of MRC, the entomology staff carried out longitudinal monitoring of various entomological parameters. Progress during the current year is given below.

Study on vector bionomics: Indoor resting mosquitoes were sampled by pyrethrum spray collection (PSC) method from 16 malaria units in six municipal corporation zones. Similarly, light trap collections (LTC) were made using CDC miniature light traps. All-night human landing collections (HLC) were made from dusk-to-dawn in one representative unit in each of the six zones of the SMC, once in a month.

PSCs (January-December) in 16 malaria units of six municipal zones (192 rooms/month) yielded 7925 anophelines (3.44/room). Although *An. stephensi* (n = 309, 0.13/room) and *An. culicifacies* (n = 29,

0.01/room) were caught in low numbers, the former was present throughout the year and was most abundant during July (0.38/room). *An. stephensi* comprised 3.9 per cent among all anophelines represented by nine species. Anopheline fauna was dominated by *An. subpictus* (92.35 per cent). Anophelines comprised 27.27 per cent whereas, *Aedes* (n = 433) and *Culex* species. (n = 20,701) accounted to 1.49 and 71.24 per cent respectively. The room density of *An. stephensi* remained low from January-April (0.02-0.09) and thereafter, showed an increasing trend and attained the peak during July, after which it again started declining. *Culex* species contributrd maximum to the total mosquito density which remained high during the first quarter of the year (13.94-18.01/room). It declined during the second quarter (5.20-9.76/room) to attain the peak during August (20.88/room) after which it once again declined and fluctuated between 9-12/room. *An. stephensi* was most abundant (0.34/room) in the west zone of the city and also the room density of all anophelines too was maximum (12.31/room) in this zone. This was mainly because of large-scale ongoing constructions of residential and commercial complexes. The average room densities of *Aedes* and *Culex* species were highest (0.29 and 10.8/room respectively) in south-west zone.

LTCs (64 trap nights/month) yielded 10,214 mosquitoes (13.3/trap night) and 1009 anophelines (1.31/ trap night). Anopheline fauna was represented by eight species and dominated by *An. subpictus* (76.61 per cent). LTCs yielded very few specimens of *An. stephensi* (n = 30, 0.04/trap night), which was found throughout the year except in March and August. *Aedes* (n = 691, 0.9/trap night) and *Culex* species (n = 8514, 11.09/trap night) were captured in good numbers all throughout the year. The latter species comprised 83.36 per cent of the total mosquitoes collected, followed by anophelines (9.88 per cent) and *Aedes* species (6.77 per cent). *An. stephensi* was conspicuously absent in the north zone throughout the year, whereas it was abundant in the west and central (0.06/trap night) and in the southwest (0.07/trap night) zones. Prevalence of *Aedes* and *Culex* species was highest in the west (3.68/trap night) and the southwest (16.45/trap night) zones respectively.

HLCs (indoor+outdoor) carried out from January to July 2000 (74 man nights) yielded very few anophelines and the average landing rate was recorded as 0.62/man night (n = 46). The average landing rate of *An. stephensi* was recorded as 0.47/man night (n = 35). Only three anopheline species were represented in all-night human landing collections. *An. stephensi* appeared to be the more exophagous (0.61/man night) rather than endophagous (0.37/man night) and it was found to be active throughout the night showing bimodal biting rhythm with the first peak in biting activity between 2200 and 2300 hrs (11.32 per cent) and the second between 0100 and 0200 hrs (16.98 per cent). The landing rates for *Culex* (n = 5113) and *Aedes* species (n = 89) were recorded as 69.09 and 1.2 per man night respectively.

To determine the prevalence and distribution of three forms of *An. stephensi*, viz. type-form (14-22) intermediate (12-17) and var. *mysorensis* (9-15); egg-float ridge numbers were counted. Ridges on the egg-floats counted for 201 females collected from all over the city revealed the dominance of type-form (59.2 per cent) followed by intermediate (38.8 per cent) and var. *mysorensis* (2 per cent). No definite pattern of the distribution of three *An. stephensi* forms in the city was observed. Samples of blood meal and head and thorax of vectors have been preserved for processing by ELISA.

Sporozoite/blood meal ELISA: Abdomens of vector mosquitoes containing fresh or partially digested blood were smeared onto filter paper for host identification. Head and thorax of the vector were stored in eppendorf tube with silica gel individually for processing by sporozoite ELISA. So far 1397 samples of head and thorax (PSC + LTC + hand catches) and 280 of mosquito blood meal, mainly of *An.*

stephensi (261) have been collected. Two samples of head and thorax of *An. stephensi* have been found positive for *P. falciparum* sporozoite.

Mosquito breeding in domestic sources: Five different land-use areas (approx. 500 X 500 m) representing slum (528 houses), agricultural area (175 houses), high rise (12 buildings), society (444 houses) and typical rural (133 houses) have been selected as sentinel sites for assessing breeding potential of domestic breeding sources. In addition, special surveys of ongoing major constructions are also undertaken to assess the breeding potential of water sources associated with them.

In the 13 surveys carried out throughout the year 1,03,909 domestic breeding habitats were checked in 16,402 houses visited. In all 675 (0.65 per cent) habitats were found with mosquito breeding and 505 (0.49 per cent) containers for anophelines. Maximum (2.01 per cent) sources were found with breeding in high rises followed by peri-urban agricultural area (1.63 per cent). Latter also supported maximum (1.32 per cent) breeding of anophelines followed by societies (0.67 per cent) and typical rural type setting (0.6 per cent). Among the domestic water storage practices checked, ground level tanks supported maximum breeding (3.2 6 per cent) followed by overhead tanks (2.63 per cent) and barrels (1.23 per cent). Underground tanks, jerry cans, mud pots and others accounted for less than one per cent breeding positivity. The average Brateau index was recorded as 0.47, which was largely contributed by high rises (1.23) followed by rural type area (0.93) and slums (0.47). During the first quarter of the year, proportion of containers with anopheles breeding ranged from 0.26-0.32 per cent followed by 0.51-0.91 per cent in the second quarter. Proportion of breeding positive containers for Anophelines further declined during the third (0.68-0.77 per cent) and the fourth (0.39-0.48 per cent) quarters. *An. stephensi* was observed to breed predominantly (> 97 per cent) in containers found positive for *Anopheles* breeding in all areas except in slums. In the construction sites (132), only 85 (0.29 per cent) water collections were detected with *Anopheles* breeding from the total 29,467 checked.

Evaluation of insecticide susceptibility and median knock-down rates: Susceptibility tests using laboratory reared and sugar fed *An. stephensi* (F_1) against deltamethrin, cyfluthrin and lambdacyhalothrin showed 92.3 per cent (n = 300), 92.3 per cent (n = 180) and 89.8 per cent (n = 180) mortality, respectively, which is indicative of development of tolerance. These insecticides are being used for indoor residual spraying in the malaria control programme in the city for the last few years. The median knock-down time (in minutes) of *An. stephensi* against these insecticides was recorded as 13.9 (n = 198), 12.1 (n = 99) and 15.2 (n = 165) respectively. The median knock-down tests will now be carried out using fully susceptible strains to compare the results. Both the adult susceptibility and the median knock-down tests were also being carried against *Ae. aegypti* and *Cx. quinquefasciatus*.

Additionally, the median knock-down time was also recorded by exposing 11 specimens in three replicas of the three mosquito species. The median knock-down time for *An. stephensi* against deltamethrin, cyfluthrin and lambdacyhalothrin was recorded as 13.9 (12.3-17.3), 12.1 (9 -14.7) and 15.2 (14-16.7) min respectively. Similarly, for *Ae. aegypti* and *Cx. quinquefasciatus* these were 11.3 (9.7-11.3), 8.9 (7.7-10), 15.6 (13.7-18.3) and 49.7 (46-53.3) and 23.3 minutes respectively. *Cx. quniquefasciatus* was not tested against lambdacyhalothrin. The median knock-down times of the three mosquito species from non-synthetic pyrethroid sprayed areas will be evaluated for the comparison purpose.

Evaluation of drug sensitivity: Sensitivity of *P. falciparum* to chloroquine was evaluated following 7-day WHO *in vivo* test procedure. Twenty-five subjects from Adajan unit in (west zone) were administered chloroquine at the rate of 25 mg/kg body weight (adult dose) in three divided doses (10 mg + 10 mg + 5 mg) spread over three days and were followed-up for seven days. Results indicated RIII level of resistance in four subjects (16 per cent), RI late in three (12 per cent) and 18 (72 per cent) subjects were classified as S/RI. The results are indicative of prevalence of drug resistant *P. falciparum* foci and more tests have been envisaged covering different ethnic groups including migrant population and large sample size so as to delimit the distribution of drug resistant foci within the city.

Future plan: A KABP study of the urban community in relation to water storage practices leading to vector breeding and malaria conditions has been planned. The outputs of this will be fed into the development of IEC package and training of the personnel involved in the urban malaria control in future, as well as planning environmental and engineering methods of vector control. It is envisaged to assess the need for alternative methods of mosquito control through geographical reconnaissance of all breeding sources so as to reduce the dependence on insecticides and larvicides. It is planned to develop a geographic information system (GIS) based malaria action plan for Surat. To achieve this it is proposed to establish a GIS facility at MRC, Nadiad during the proposed extension period.

Phase II evaluation of bifenthrin 10% WP and fipronil 80% WDG indoor residual spraying for malaria vector control in India

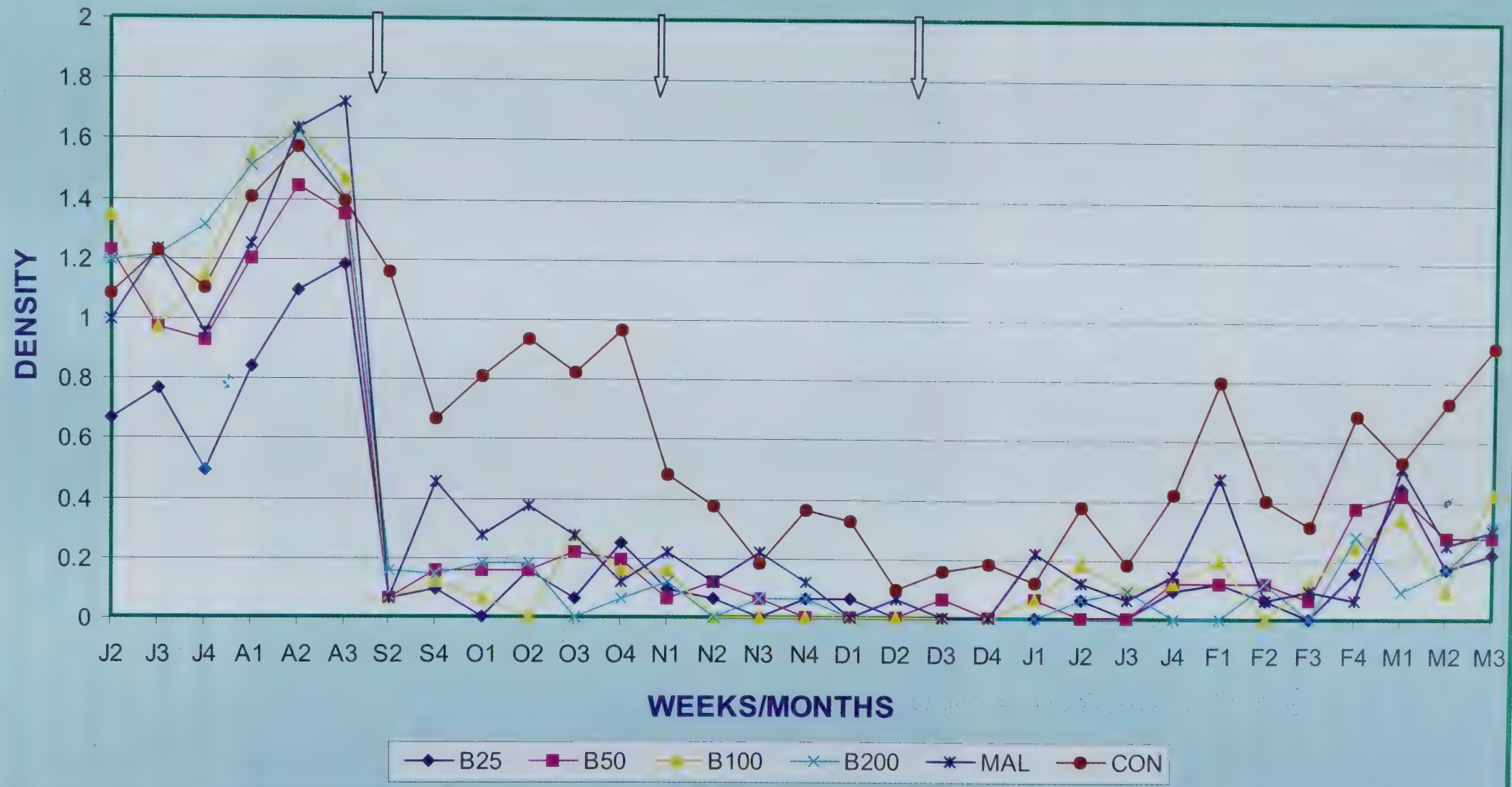
Objectives of the study were:

- To compare the persistence of bifenthrin WP (25, 50, 100 and 200 mg/m^2), fipronil 80 per cent WDG (25, 50 and 100 mg/m^2) and malathion WDP (2 g/m^2) on different local surfaces.
- To compare the efficacy of bifenthrin and malathion on entry rate, indoor resting density, excito-repellency, immediate and delayed mortality and success in feeding.
- To determine the best application dose for the future (phase III) study.
- To record perceived side effects by spray men and inhabitants of the sprayed rooms.

Entomological studies were conducted in five riverside villages of Thasra taluka in Kheda district. Survey of side effects was conducted in an adjacent village. In each of the five villages, nine comparison houses were selected and based on the baseline entomological surveys for six weeks during July and August 1999, these were randomised to following nine arms of comparison, i.e. bifenthrin four arms (25, 50, 100 and 200mg/m^2, one round of spraying), fipronil three arms (25, 50, and 100 mg/m^2 , one round of spraying), malathion one arm (2 g/m^2, three rounds of spraying at six weeks apart) and unsprayed control.

The intervention phase was from September-March 2000 during which contact bioassays to determine persistence of the biological efficacy of insecticides on major local surfaces such as tin-sheet, wooden surface, brick-walls and mud-walls, airborne bioassays, entomological collections (hand and pyrethrum collection, window traps) and a questionnaire based study on perceived side effects by spray men and householders were carried out.

Geometric mean density of An. culicifacies in houses sprayed with bifenthrin (25, 50, 100 and 200 mg/sq.m.) and malathion (2g/sq.m.) in Kheda district, Gujarat



Conclusions of bifenthrin trial: Susceptibility of the local population of *An. culicifacies* to bifenthrin (0.1 per cent) at one-hour exposure and 24 h holding showed cent per cent knock-down/mortality. The mortality with malathion (5 per cent) impregnated test papers was 57 per cent. During the study blood meals of 686 *An. culicifacies* were examined and of these 17 (2.5 per cent) had fed on human blood, 435 (63.4 per cent) on cattle and 234 (34.1 per cent) on other hosts. Out of 686 females, semi-gravid ovaries of 154 were collected for sibling species identification, of which 100 ovaries could be identified. Of these, 10 were of species A, 74 of species B and 16 species C. It may be noted that B is a non-vector species. Thus, vector species A and C together accounted for 26 per cent in the trial villages and the overall anthropophilic index was 2.5 per cent.

The persistence of bifenthrin was most superior on tin surface compared with other surfaces like mud walls, wood and brick-walls. However, since the mud-plastered walls were more common in the rooms, persistence of residual action on mud walls should be the basis for selecting a dose for the phase III trial. On mud walls 25 mg bifenthrin produced cent per cent mortality up to eight weeks, >80 per cent until 20 weeks and 66.7 per cent by 24 weeks. With 50 mg the residual effect on mud walls was cent per cent

until eight weeks and > 80 per cent until 24 weeks. Thus, the dose of 50mg/m^2 was found to have a marginally better residual action. The airborne effect of these two doses was nearly comparable and was short lasting. Effect of 25 and 50 mg dosage on indoor resting densities was also comparable. The excito-repellent effect was generally higher with bifenthrin or malathion compared to control. There was however no difference in excito-repellency between bifenthrin and malathion, or among the various dosages of bifenthrin. Since the air-borne effect was seen up to first two weeks and subsequently declined to negligible levels. Bifenthrin was perceived to be safe by the spray men and the householders.

Conclusions of fipronil trial: The persistence of residual action and airborne effect of the single round of fipronil at 25, 50 and 100 mg/m^2 dosages was either similar or inferior to the currently used insecticide, i.e. malathion sprayed in three rounds. Although the indoor resting densities of malaria vector in fipronil sprayed houses were marginally lower than in the control rooms, there was no marked difference when compared to malathion sprayed rooms. Other entomological parameters also showed that fipronil had either similar or lower insecticidal effect. The communities and the spray men however, generally reported that fipronil had no apparent adverse effect on their health. Keeping in view of entomological impact, further evaluation of fipronil has not been suggested.

Phase III trial of bifenthrin and deltamethrin: Based on the results of phase II trial, the phase III evaluation of bifenthrin 10 per cent WP and deltamethrin 25 per cent WG indoor residual spraying for malaria vector control was started in July 2000 with the objectives : (a). to compare the persistence of bifenthrin 10 per cent WP and deltamethrin 25 per cent WG at 25 mg/m^2 dose on common local surfaces; (b). to compare the impact of bifenthrin and deltamethrin indoor residual spraying on the elements of vectorial potential, such as on the resting and biting density, blood feeding rate, survival rate and sporozoite rate, and on vector behaviour; (c). to record possible side effects on spraymen and perceived side-effects by inhabitants of the sprayed rooms; and (d) to measure cost-effectiveness of bifenthrin and deltamethrin indoor residual spraying compared to malathion indoor residual spraying. Study villages have been selected and entomological activities as planned are in progress. Under phase III baseline entomological studies will continue until June 2000 and thereafter the study villages will be randomised to receive interventions.

Malaria clinic

A total of 4435 blood smears of patients with fever were examined at the malaria clinic.A total of 151 blood smears were positive for malaria (*Pv* = 108, *Pf* = 41, *Pv* + *Pf* = 2; and SPR = 3.5 per cent) with 28.5 per cent *P. falciparum* infections. A total of 575 blood smears collected from Mehsana district were received from the state health authorities for examination in the month of March 2000, of which one was found positive for malaria parasite.

Evaluation of rapid diagnostic test kits

Rapid malaria diagnostic kits Paracheck (n = 396) and OptiMAL (n = 96) were evaluated in the malaria clinic. The sensitivity of Paracheck for *P. falciparum* parasites was 93.3 per cent, while that of OptiMAL was 93.3 and 83.3 per cent for *P. vivax* and *P. falciparum,* respectively.

Training workshops organized

On the request of health authorities, three capsule training courses in malaria microscopy for Laboratory Technicians were organized in the months of February and March 2000. About 49 Laboratory Technicians of different districts and Municipal Corporations participated in the training courses. Brief lectures were delivered on malaria diagnosis to 119 students of Medical Laboratory Technical Institutes of Anand, Borsad and J & J College, Nadiad during their visits to the field station.

Training received

1. Dr. R.M. Bhatt attended 12-week training course in Entomology and GIS at the London School of Hygiene and Tropical Medicine, U.K. from 14 February-15 May 2000.

2. Dr. S. Haq participated in the training course on Blue-Green Algae at IARI, New Delhi from 20-30 March 2000.

Participation in conferences/workshops

1. Dr. R.S. Yadav participated as faculty in Medical Entomology course organised by MRC, Delhi from 20-21 January 2000.

2. Dr. H.C. Srivastava attended V International Symposium on Vector and Vector- borne Diseases at Patiala from 16-18 February 2000 and presented a paper entitled, "Malaria associated with a water resource development project in Gujarat".

3. Dr. R.S. Yadav attended XIV National Congress of Parasitology held at Delhi from 24-26 April 2000 and presented a paper entitled, "Integrated control of vector-borne diseases in Ahmedabad".

4. Dr. R.S. Yadav participated in the USAID-Environmental Health Programme sponsored Inter-country workshop on cross-border issue in malaria, kala-azar and J.E. prevention and control at Hetauda, Nepal from 24-28 July 2000.

6.2 JABALPUR (MADHYA PRADESH)

The field station is presently engaged in applied field research, sponsored clinical and diagnostic trials and epidemic investigations on the request of the Govt. of Madhya Pradesh. During the year following studies were carried out.

Malaria clinic

During the year 4309 febrile patients attended the malaria clinic located at Medical College Hospital, Jabalpur, of which 254 malaria positive cases were detected. These included 126 *P. vivax*, 126 *P. falciparum* and two mixed infections of *Pv* and *Pf*. The SPR, SfR and *Pf* per cent were 5.9, 2.9 and 49.6, respectively. All the positive cases were given treatment as per NAMP drug schedule and cases reported to DMO Jabalpur for follow-up measures.

Clinical Trials of Antimalarial Drugs

A randomized, double blind, comparative study of azithromycine vs. chloroquine as a treatment of *P. vivax* malaria: A double blind clinical trial of azithromycine vs. chloroquine in *P. vivax* malaria patients was completed in collaboration with Department of Medicine, Govt. Medical College Jabalpur as a part of a multicentre study by the sponsorship of M/S. Pfizer India Ltd. Ten patients having vivax malaria were enrolled during the year. All responded well to the drug and completed 28 days follow-up without any complication and adverse effect and became free from asexual parasitaemia on Day 3.

Clinical trial with azithromycine and chloroquine combination in the treatment of *P. falciparum* and *P. vivax* malaria : This study has been initiated in December in collaboration with Department of Medicine, Govt. Medical College, Jabalpur. One patient with *P. falciparum* was enrolled and successfully treated with these two drugs. Asexual parasitaemia and symptoms cleared within 48 h.

Evaluation of drug 80/53: During the year two cases of *P. falciparum* having gametocyte infection were included in the study. For both the cases membrane feeding of *An. stephensi* mosquitoes was made on Day 0, 3 and 4. The patients were treated first with 1500 mg chloroquine (600 mg on Day 0, 600 mg on Day 1 and 300 mg on Day 2) and with 80/53 drug on Day 3. Oocysts and sporozoites were observed in mosquitoes fed on Day 0 and Day 3. No sporogony was observed in mosquitoes fed on Day 4 (after 80/53 administration).

Micro-stratification of malaria high risk area

Malariogenic stratification was considered to be an essential component for developing the appropriate malaria control measures. Mandla, a tribal forested district, has been selected. There are nine PHCs (all under EMCP), 223 sections and 1256 villages in the district. The mathematical equation used for stratification in this study had been developed by GP. Singh *et al* (1990) with some modifications taking into consideration such factors having decisive role in the malaria incidence. The factors considered were topography, average annual rainfall of last five years, vectors prevalent in the area, average API for the last 10 years, epidemic potential (the highest value of API during last 10 years) and vulnerability. The results indicate that

all nine PHC's had high risk of malaria. Further, stratification at the section level revealed that among the 223 sections, only one section fall under medium risk, while 222 sections (99.5 per cent) are categorized under high risk. Similarly, stratification at the village level revealed that out of 1256 villages, 1052 (83.7 per cent) have been found under high risk and remaining 204 (16.2 per cent) villages fall under medium risk. It was observed from this analysis that in majority of sections villages had the highest values of each factor. All efforts were made to reduce malaria morbidity and mortality by strengthening EDPT, intensified vector control measures, IEC awareness and by establishing adequate number of FTD and DDC. The drug policy needs to be changed in view of high level of chloroquine resistance against *P. falciparum* in Mandla.

Evaluation of Rapid Diagnostic Kits

Field evaluation of post-treatment sensitivity for monitoring clearance of *P. falciparum* parasites using Determine™ Malaria *Pf*: The post-treatment diagnostic performance of the *Plasmodium falciparum* histidine rich protein (HRP II) antigen detection test, Determine™ malaria *Pf* was assessed on 70 uncomplicated *P. falciparum* malaria cases treated with chloroquine (CQ), fansidar (SP), and arteether (E MAL) in comparison to thick blood films as gold standard in highly malarious tribal villages of central India. Results revealed that the sensitivity for predicting recrudescence using Determine™ rapid diagnostic test (RDT) after treatment with CQ on Day 14 was 75 per cent with 50 per cent specificity. However, anti-genemia was detected in 16 per cent patients as late as Day 21 with SP treated subjects in contrast to microscopy in which all patients reverted to become negative immediately after cure and the patients had no subsequent clinical/parasitological recurrence. Clearance of parasitaemia in thick blood smear and clearance of antigenemia appear to parallel each other only in E MAL treated subjects. The observed diagnostic trends therefore mean that the potential of RDT to monitor response to antimalarials are limited.

Assessment of the usefulness of Determine™ malaria *Pf* in the evaluation of intervention measures in forest villages of central India: *Plasmodium falciparum* is a major problem in forested tribal belt of central India. We performed a blind evaluation of the recently introduced Determine™ malaria *Pf* test (Abbott, Laboratories, Japan) compared with microscopy and splenomegaly in children in epidemic prone areas of District Mandla to assess the impact of intervention measures. Using microscopy as the gold standard, the sensitivity and specificity for the diagnostic test were 91 per cent and 80 per cent, respectively. The positive predictive values (PPV) and negative predictive values (NPV) of the test were 79 and 91per cent respectively. On the contrary, the sensitivity and specificity of spleen were 57 and 75 per cent respectively with PPV of 73 per cent and NPV of 59 per cent. The results indicated that the rapid diagnostic test is easier and quicker to perform and has other advantages over microscopy in not requiring prior training of personnel or quality control and in not being subject to variation in performance with the incidence of infection. This study, although limited by small number of children, highlights the usefulness of a rapid antigen test in assessing the prevailing malaria situation in remote malarious areas and thus, address one of the significant drawbacks to current antimalarial programme.

Evaluation of the OptiMAL: A new rapid malaria test, OptiMAL (Flow Inc, Portland, OR 97201, USA) has recently been tested on the request of drug controller of India. The OptiMAL test is a rapid 15 min test that detects and differentiates *P. falciparum* from *P. vivax*. It is based on the detection of parasite lactate dehydrogenase (pLDH). The sensitivity and specificity of OptiMAL for *P. falciparum* were 95.7 and 96.3 per cent respectively. The positive predictive values (PPV) and the negative

predictive values (NPV) were 95.7 and 96.3 per cent respectively. The sensitivity of OptiMAL for *P. vivax* was cent per cent, while the specificity was 93 per cent. The PPV was 72.7 per cent and the NPV was cent per cent. In an attempt to evaluate if the OptiMAL can be used to monitor antimalarial treatment, 25 *P. vivax* and 44 *P. falciparum* infected patients were followed-up from Day 1 to 28. OptiMAL showed good sensitivity (98-100 per cent) for the initial diagnosis of *P. falciparum* and *P. vivax* malaria and also mirrors the decline in viability of the parasites on treatment, giving the potential to follow the efficacy of the drug treatment. The OptiMAL test matched well with the blood film microscopy to monitor the antimalarial treatment and the test is capable of detecting recrudescence and reinfection of both *P. falciparum* and *P. vivax*. It could be a useful alternative to microscopy to monitor the treatment in hardcore areas where facilities for microscopy are either inadequate or not available.

Malaria potential at the Indira Sagar complex (Narmada) project in Khandwa district

Indira Sagar project is a multipurpose project with the largest storage capacity in the country. The construction of the project is still in progress. It has an installed capacity of 1000 MW and an annual irrigation of 2.65 lakh hectare. The submergence of this project will be 91,348 ha., including forest and revenue land extending to 249 villages of Khandwa, Hoshangabad and Dewas districts. Out of these proposed submerged villages, in 12 villages of Khandwa district entomological and epidemiological investigations were conducted in October. The results revealed very low incidence of malaria in these villages. A total of 157 blood smears of fever cases were collected, of which only 15 were malaria positive (7 *Pv* and 8 *Pf*). The SPR, SfR and *Pf* per cent were 9.5, 5 and 53.3 respectively. The man-hour density of anophelines was also not high (29), however *An. culicifacies* was the dominant species.

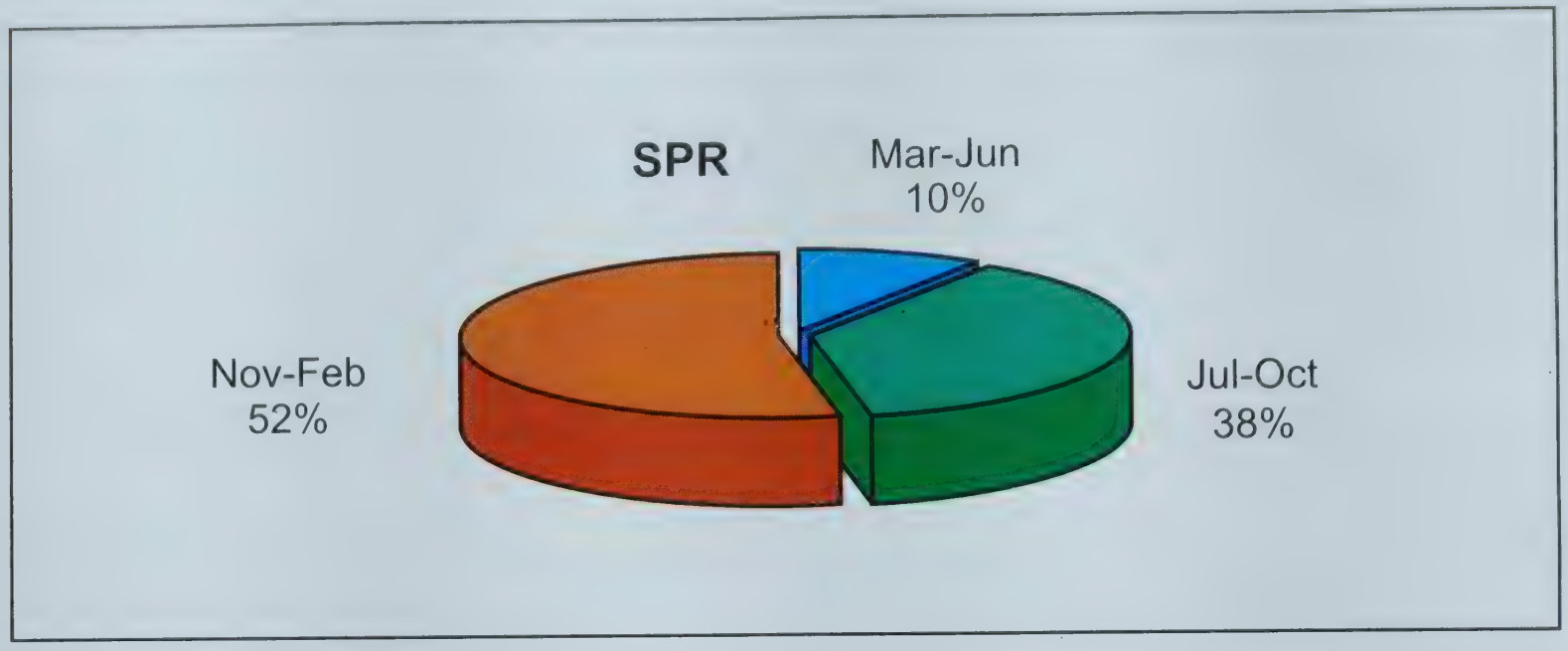
Epidemiological investigations in EMCP districts

Following districts of Madhya Pradesh under Enhanced Malaria Control Programme (EMCP) were surveyed to record the magnitude of the problem of malaria on the request of the State Government.

Hoshangabad district: About 12 villages of Suktawa PHC were surveyed in the months of September and October. These villages are highly malarious and situated near the defence proof range area and are unapproachable daily from 1000 to 1700 hrs due to defence explosive tests. A total of 477 blood smears from these villages were collected, of which 196 were malaria positive. The SPR, SfR and *Pf* per cent were 41, 36 and 88 per cent respectively. A total of 540 children in the age group of two to nine years were screened for spleen examination. The spleen rate and the average enlarged spleen were 30.2 and 1.8 respectively. About 52 children were malaria positive. The man-hour density of anophelines observed in the month of September revealed *An. culicifacies* as the dominant species (30 PMH) followed by *An. subpictus* and *An. fluviatilis*. These villages of Hoshangabad district are under intense antimalarial measures including frequent health camps by the doctors of state health department.

Betul district: Three PHCs of Betul district were the worst affected due to malaria. In all, 35 affected villages of these blocks were surveyed during October to December. A total of 2467 blood smears collected from fever patients were examined for malaria parasite. Out of 1295 malaria positive cases, 82

were *P. vivax*, 1208 *P. falciparum* and five were mixed (*Pv* + *Pf*). The SPR, SfR and *Pf* per cent were 52.5, 49.0 and 93.3 respectively.



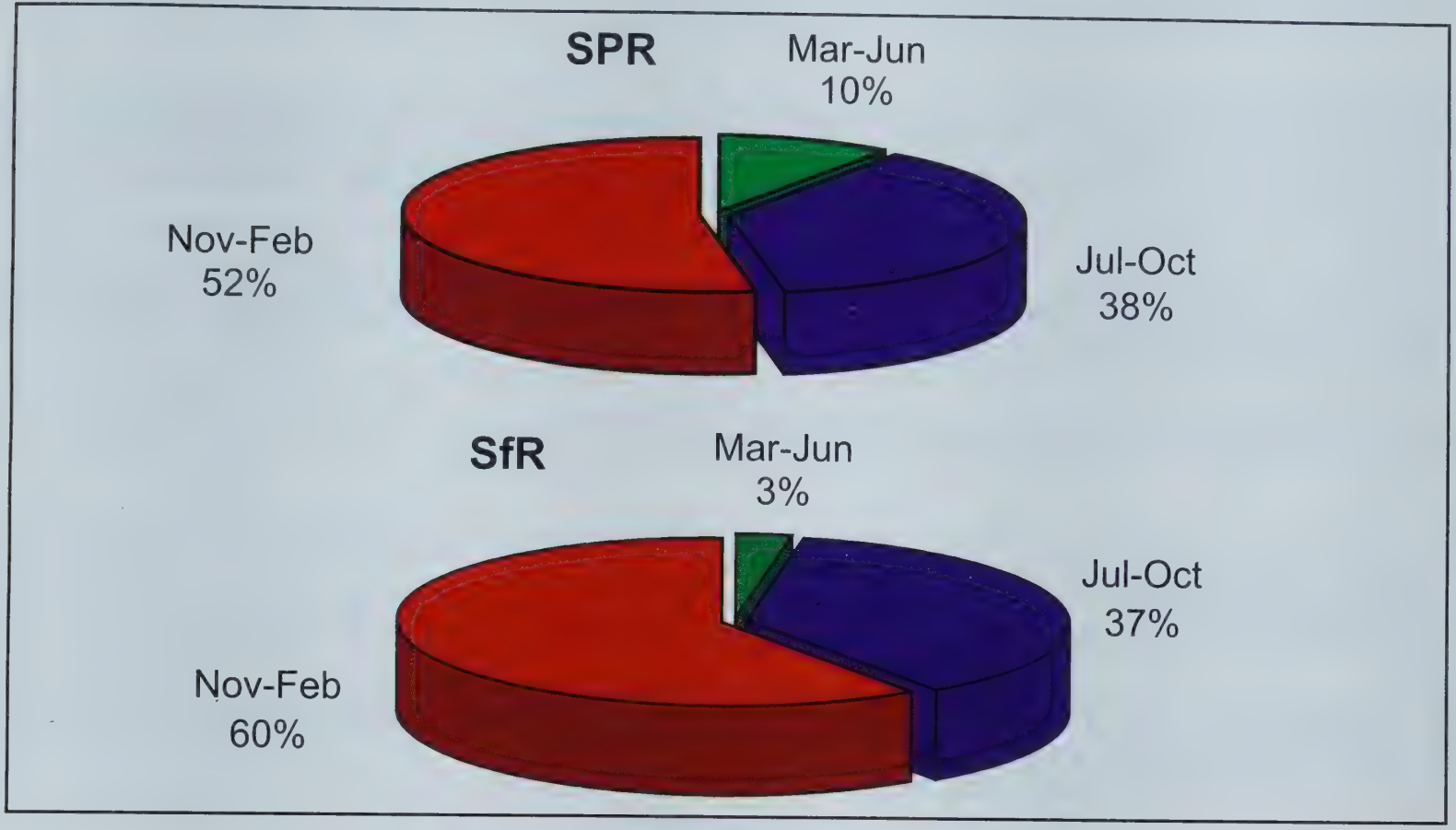
Among 696 children in the age group of two to nine years, 504 were found with enlarged spleen. The spleen rate and the average enlarged spleen were 72.4 and 1.92 respectively. The density of resting anopheline mosquitoes in these villages was not high (32.1 in October and 16.8 in December), however, *An. culicifacies* was the dominant species followed by *An. subpictus* and *An. fluviatilis*. These PHCs are under intense malaria control activities.

Chhindwara district: Cross sectional surveys were carried out in malaria affected villages of District Chhindwara in August where an epidemic of malaria broke out in 1998, for entomological and parasitological investigations as a part of post-epidemic investigation. During the year, a total of 292 blood smears of fever cases were collected, of which 68 were malaria positive (10 *Pv* and 58 *Pf*). The SPR, SfR and *Pf* per cent were 23.3, 19.9 and 85.3 respectively indicating the impact of intervention measures. Among 1005 children in the age group of two to nine years, 390 had enlarged spleen. The spleen rate and the average enlarged spleen were 38.8 and 1.8 respectively. A total of 78 children were malaria positive (27 *Pv*, 49 *Pf* and 2 mixed).

Anopheline ecology and dynamics of malaria during development of right bank irrigation canal of Bargi multipurpose dam project

To determine the anopheline ecology and incidence of malaria in the command area of right bank canal of Bargi dam, entomological and epidemiological surveys were conducted in 1999 in two villages irrigated with canal and two villages without irrigation. Results revealed that in canal-irrigated villages, malaria prevalence is higher in comparison to that of in others. A total of 170 blood smears were collected in canal-irrigated villages, of which 44 were malaria positive (19 *Pv* and 25 *Pf*). The SPR, SfR and *Pf* per cent were 25.9, 14.7 and 56.8 respectively. In non-irrigated villages 109 blood smears were collected, of which only 18 were positive (11 *Pv* and 7 *Pf*). The SPR, SfR and *Pf* per cent were 16.5, 6.4 and 38.9 respectively. Entomological observations revealed higher anopheline density (48.8) in canal-irrigated

villages as compared to others (39.0). A total of nine anopheline species were caught in resting collections, of which *An. culicifacies* was the dominant species in both groups of villages. The parous rate of *An. culicifacies* was 57.4 per cent in canal-irrigated and 53.4 per cent in non-irrigated villages.



Follow-up investigation of malaria outbreak in villages near Bargi dam reservoir, Mandla

Follow-up investigations of malaria outbreak in villages of Narayanganj PHC near Bargi dam reservoir were carried out to assess the impact of intervention measures. Analysis revealed that out of 1159 blood smears collected from fever cases, 587 were malaria positive (41 *Pv*, 531 *Pf* and 15 mixed infection of *Pv* and *Pf*). The SPR, SfR and *Pf* per cent were 50.6, 45.8 and 90.4 respectively indicating very high prevalence of malaria especially in post-monsoon months.

Observance of antimalaria month

During the antimalaria month (June) 93 group meetings and 24 health camps in 22 villages of Mandla and Jabalpur districts were organized, in which a total of 3698 villagers participated. They were told about various methods of protection from mosquito bites, elimination of breeding sites and early diagnosis and prompt treatment. During the health camps 158 children were screened for the spleen examination, of which 30 had enlarged spleen. Only three were malaria positive. Besides, 105 blood smears of patients suffering from fever were collected, of which 12 were malaria positive. For public awareness a radio talk on 'Malaria aur Bachav' by Dr. A. K. Mishra was broadcasted on Akashwani Jabalpur on 30 June 2000. Some articles related to malaria and mosquitoes were published in local newspapers during antimalaria month.

Meetings/Conferences attended

Dr. Neeru Singh attended the following meetings:

(i) WHO meeting from 3-5 January at Chandigarh and presented a paper on "Personal protection and home care through empowerment of women".

(ii) International symposium on vector and vector-borne diseases, 16-18 February at Patiala and presented a paper on "Anopheline ecology and malaria transmission at Bargi" and to received the best scientist award.

(iii) National Congress of Parasitology, 23-26 April in Delhi and presented a paper on "Malaria during pregnancy and infancy in a tribal area of central India".

Dr. Neeru Singh and Dr. M.M. Shukla attended the following meetings:

(i) The Pfizer sponsored clinical trial study monitoring meeting, 21-22 February, 27- 28 June, 12-14 July, 6-8 September and 23-25 December in Jabalpur.
(ii) Symposium on "Clinical update" for azithromycin drug trial, 17 September in Delhi.

(iii) Visited Raipur on 4 December as part of a central team to suggest short-term and long-term antimalarial measures for Chhattisgarh.

6.3 HARDWAR (UTTARANCHAL)

Determination of chlorproguanil-dapsone and their metabolites in plasma to study pharmacokinetic parameters after giving LAPDAP (work carried out at the University of Liverpool, U.K. during Wellcome Trust Fellowship)

Chlorproguanil/dapsone combination (LAPDAP) is being investigated for the treatment of uncomplicated *P. falciparum* malaria and is in pivotal in Phase III clinical trial. Different combinations of mobile phases consisted of acetonitrile-methanol-water-trifluoroacetic acid (TFA). These analyzed to get the separation of dapsone, monoacetyl dapsone and pyrimethamine (internal standard) in one group and chlorproguanil, cyclochlorproguanil and proguanil (internal standard) in the other group. Mobile phase consisted of acetonitrile-methanol-water-TFA (50:30:225:100 µl) which gave baseline separation of dapsone, monoacetyl dapsone and pyri-methamine, while actonitrile-methanol-water-TFA with solvent composition of 90:45:225:100 µl separated cyclochlorproguanil, chlorproguanil and proguanil @100 ml min^{-1} on C_{18} reverse phase column. The detections of all compounds were performed at 254 nm UV-detector.

Dapsone and its metabolites were extracted from plasma in phosphate buffer pH 5:2 by using dichloro-methane while the chlorproguanil group compounds were extracted at pH 8 by diethylether. The recovery of all compounds was in the range of 85-92 per cent. Calibration curves for dapsone, monoacetyl dapsone, chlorproguanil and cyclochlorproguanil were found linear with the correlation coefficients above 0.99. The method has also been extended to find the concentrations of these drugs in whole blood spiked on filter paper for field applications. The method was initially used to find the concentrations of dapsone and chlorproguanil in LAPDAP drug and gave accuracy above 95 per cent.

Search for a new sulfonamide as antimalarial drug

Oxidation of sulfadoxine was carried out with peroxydisulfate ion in presence of Ag ion as a catalyst to get different products formed during the oxidation process. The reaction mixture turned yellow within 10 min after initiation and then became dark-yellow to brown, and finally dark-brown precipitates were formed within 24 h. Column chromatography on silica gel column yielded four bands after gradient elution. A high performance liquid chromatographic method has been developed for the separation of different compounds formed during the reaction. A mobile phase consisting of acetonitrile-methanol-water (25:9:95) @ 1 ml min^{-1} on C_{18} reverse phase column separated all oxidation products. The detection was performed at UV-254 nm. Further studies are in progress.

Isolation, characterization and antimalarial activity of different compounds of *Andrographis paniculata*

After ascertaining substantial schizontocidal activity of some compounds isolated by *in vivo* and *in vitro* methods, studies were diverted to isolate more amounts of major compounds to investigate their structures and to further test their antiparasite activities. A high performance liquid chromatographic method has been developed to check the purity of different compounds isolated from the roots of *A. paniculata* by using a combination of column and thin layer chromatographic techniques. A mobile phase consisting of methanol-water (80:20) was pumped @ 1 ml min^{-1} onto C_{18} Bondapak reverse phase column for the separation

of different compounds. UV-detector operated at 254 nm detected all compounds. The compounds coded as APR1, APR2, APR3, APR4, APR5 and APR7 were found pure by this method with their retention times of 7.4, 6.4, 2.8, 2.8, 3.4 and 2.9 min respectively. The ultraviolet spectra of all compounds were also recorded. The proton NMR spectra of all five compounds were also recorded. Further, NMR and MS experiments are in progress to elucidate their structures. About 5-10 mg of each compound was sent to WHO for *in vitro* screening of different parasite species.

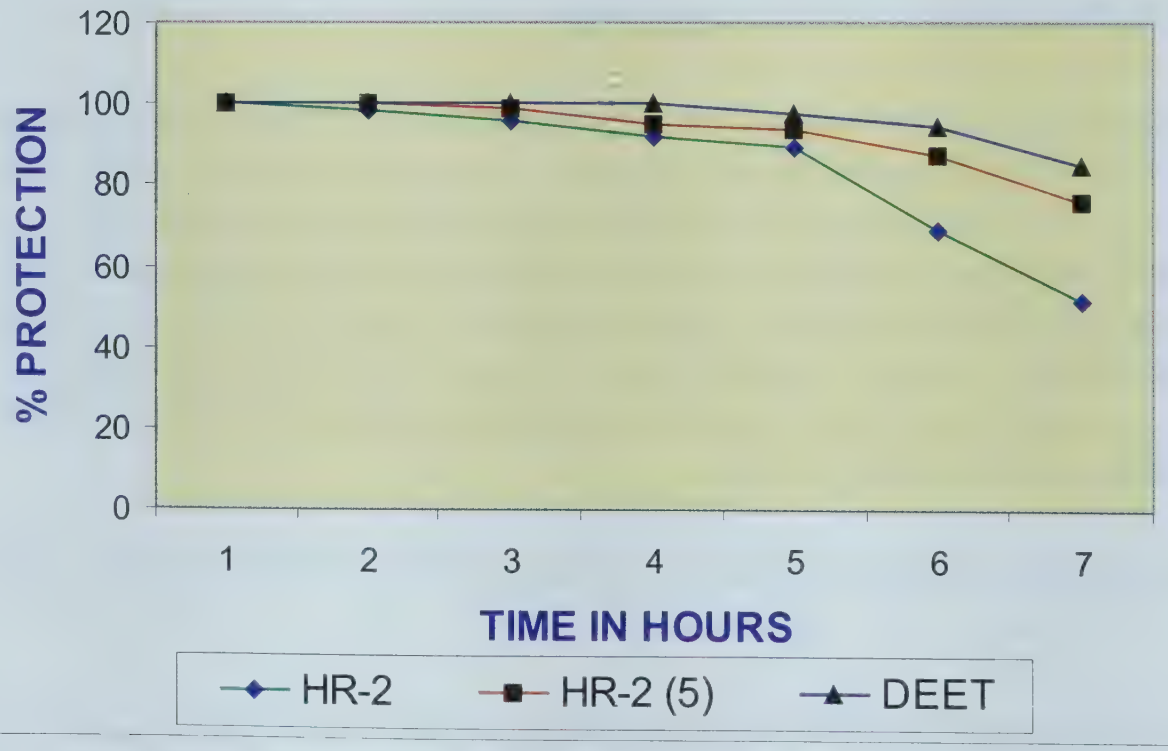
Synthesis of 6-methoxy 5-8 di-(4-amino methyl butyl amino) quinoline

The project was undertaken in collaboration with CDRI. Primaquine was converted to its base and the amino group was protected. Nitration of the protected primaquine base furnished a mixture of mono, di and polynitro products. Separation of the mixture by preparative TLC gave dinitroproducts with traces of mono-nitro product. Assignment of the position of nitro group in the mono-nitro product is under investigation. Alternatively 8-amino-6-methoxyquinoline has been prepared in four steps. Nitration of this is in progress.

Mosquito repellency of *Lantana camara* flowers

The repellency of fraction HR-2(5) of *Lantana* flowers against *Aedes* mosquitoes under field conditions was tested. Application of HR-2(5) on human volunteers resulted 75.8 per cent protection upto seven

Field Trials with the fractions HR-2 and HR-2(5) of *Lantana* flowers and Diethyl toluamide (DEET) for the repellent activity against *Aedes* mosquitoes

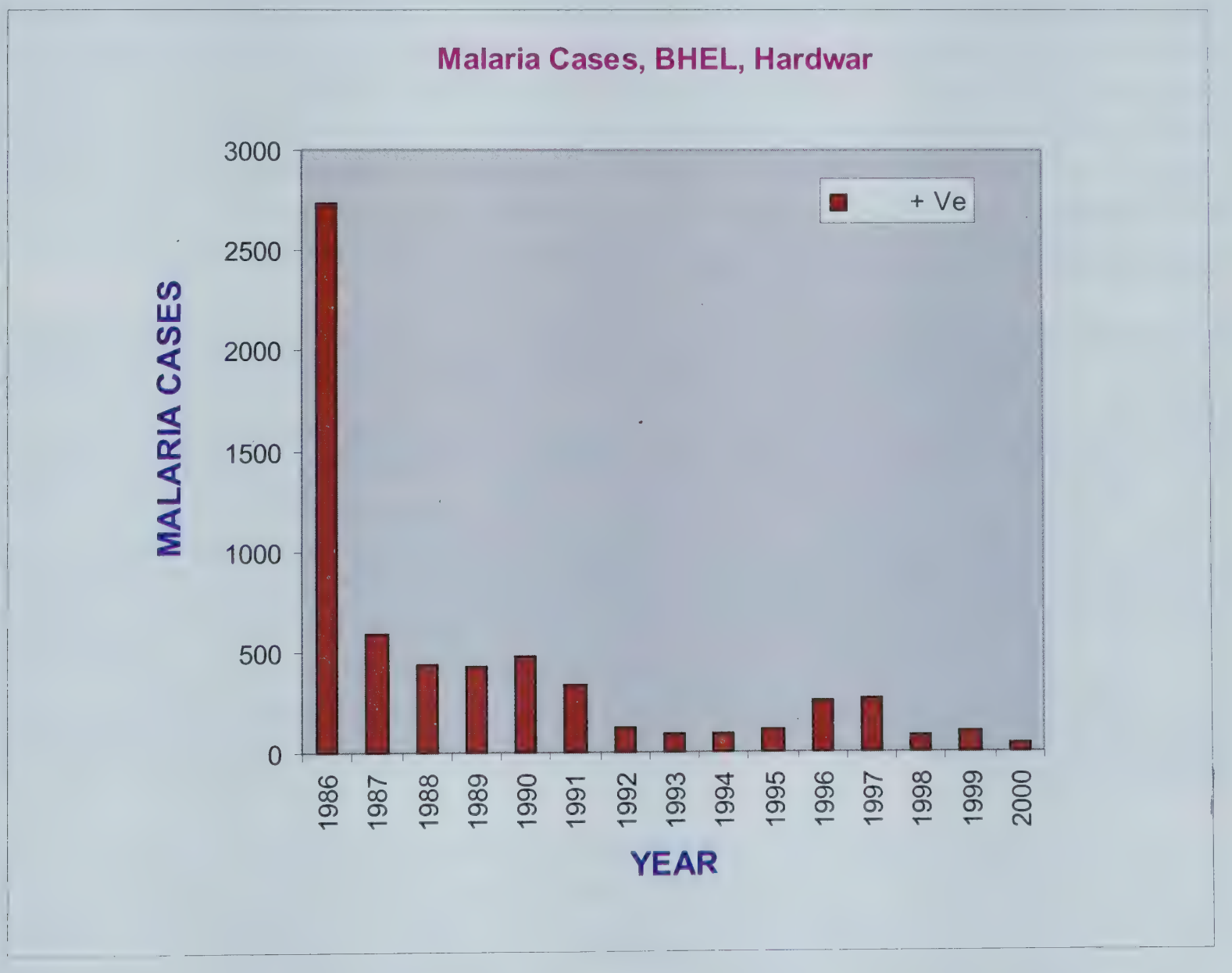


hours after its application. It may be noted that HR-2(5) gave cent per cent protection for two hours. A total of 2045 *Aedes* were collected from control and 1821 (89.1 per cent) were *Ae. albopictus* and 11 per cent were *Ae. vittatus* and *Ae. Aegypti,* whereas in treated group 138 (92.8 per cent) were *Ae.*

albopictus and others were *Ae. vittatus* and *Ae. aegypti* during the total follow-up of seven hours. Fraction HR-2(5) was further separated into five pure fractions by TLC methods. Preparative TLC was performed to isolate sufficient amount of pure compounds to test their repellencies. Laboratory experiments indicated that the pure compounds possessed very low repellency against *Ae. albopictus* mosquitoes. Therefore, it is concluded that some synergistic effect may play a major role for the repellent behaviour of HR-2(5). Thus, further purification is not required.

Industrial malaria control

BHEL, Hardwar: At BHEL, Hardwar, regular intervention work has been withdrawn from BHEL for the last nine years. The density of *An. culicifacies* in the township was found low as compared to control area and was confined to riverine area during monsoon season. A total of 45 malaria cases including six *P. falciparum* cases were recorded out of 2538 blood slides examined for malaria parasites. All the *P. falciparum* cases were imported.



The malaria cases in the year 2000 were lowest since the inception of the project at BHEL, Hardwar in 1986. A total of 1500 *P. vivax* cases were followed to know the relapse pattern and 121 (8.06 per cent) cases relapsed after administration of 5-day radical treatment with primaquine. The second and third relapses were also observed in 17 (1.13 per cent) and 2 (0.13 per cent) cases respectively inspite of 5-day radical treatment each time.

IDPL, Rishikesh and IOC, Mathura: It was without intervention since 1991 and even malaria cases were also lowest in 2000. Only eight cases were recorded which implied that the bioenvironmental control strategy is long lasting. About 163 malaria cases were detected at Malaria clinic, IOC, Mathura out of 1791 blood slides examined with a SPR of 9.1 per cent. Only 13 cases had *P. falciparum* parasites. It is to point out that the malaria cases recorded in 2000 were lowest since MRC started intervention measures in 1991. Moreover, *P. falciparum* cases were also recorded lowest during last nine years.

NTPC, Rihand Nagar: One of the aims of the field station at Hardwar is to provide consultancy services to control malaria at various industries. MoU was signed to control malaria at NTPC, Rihand Nagar in 1999 for three years. Two surveys were carried out in March and July 2000. Fish hatcheries of Guppy are being established in various water reservoirs. EPS beads are being applied in sluice-valve chambers. Low lying areas and small pits are being filled with TPS fly ash. 58 (10.5 per cent) of 577 breeding source surveyed in township had mosquito larvae. Only 3.4 per cent were positive for *Anopheles*. The survey of plant area and adjoining villages revealed 34 per cent and 17 per cent habitats positive for mosquito larvae. *An. culicifacies* is the only major vector species present at NTPC area. A total of 176 (SPR 9.14) cases were found positive for malaria and 94 cases were identified with *P. falciparum* infection, while 82 cases were of *P. vivax*. A cross examination of slides revealed that many cases (20 per cent) were identified as false positives. It is suggested to train technicians for proper examination of blood slides for malaria parasites. It was recommended to reduce the consumption of antimalarials particularly artesunate and mefloquine.

Investigations on malaria at Laksar PHC of District Hardwar

Parasitological and entomological surveys were carried out in different villages of Laksar PHC of District Hardwar on the request of Chief Medical Officer, Civil Hospital, Hardwar. All blood slides collected by DMO office were also examined by MRC, Hardwar. Parasitological data revealed that out of 5536 blood slides examined for malaria parasites, 731 were found positive for malaria with a SPR of 13.26 per cent. About 439 cases were identified with *P. falciparum* infection, while 292 cases had *P. vivax* malarial parasites. Among 393 *P. falciparum* positive blood slides, 224 (57 per cent) slides were gametocyte positive. *In vivo* and *in vitro* sensitivity tests were performed to find the response of *P. falciparum* to chloroquine. About 55 isolates were tested *in vitro* and growth occurred in 46 and 28 isolates had MIC value above eight picomole thus indicating resistance to chloroquine, while other 18 isolates had MIC value of eight or below indicating their sensitivity. *In vivo* test of 37 cases revealed that 24 *P. falciparum* cases were sensitive, while 13 (35.13 per cent) were resistant (RI) to chloroquine. All resistant cases responded to fansidar.

Out of 782 anophelines collected, 40.2 per cent were *An. fluviatilis* followed by *An. annularis* (18.5 per cent), *An. aconitus* (12.4 per cent) and *An. culicifacies* (8.8 per cent). *An. culicifacies* and *An. fluviatilis* were the two major primary vector species prevalent in this area. The density of *An. culicifacies was* high during pre- and monsoon season, while that of *An. fluviatilis* was high in post-monsoon season. A breeding source survey of anophelines was also carried out, which showed that a tributary river of the Ganges is a permanent breeding site for the anophelines. *An. culicifacies* (40 per cent) were resistant to DDT, while *An. fluviatilis* was found fully sensitive to DDT. Studies are in progress to identify the sibling species complex of *An. fluviatilis* and the human blood meal index (HBI) to determine its role in malaria transmission in Laksar PHC.

Technical support and health education activities

1. A team from MRC visited NTPC, Rihand Nagar from 20-31 March 2000 for antimalarial activities. Another team also visited NTPC, Rihand Nagar from 17-31 July 2000 for follow-up action on malaria control activities.

2. Two students from Gurukul University carried out project work for their M.Sc degree.

3. Four health camps were organized at malaria epidemic villages Dargahpur, Durgapur, Aushpur, Ismilepur in Laksar PHC of District Hardwar.

4. Dr. V.K. Dua, Mr. S.P. Sethi, Jog Raj, P.P. Pant, Amlesh Tyagi and G.S. Negi participated in the *Health Mela* held at Mathura organized jointly by the Central and State Government from September 17-20, 2000. MRC, Hardwar Unit put an exhibition on Bioenvironmental control of malaria at the *Health Mela*. Hon'ble Union Health Minister visited the exhibition on 17 September 2000 and was apprised about the strategy.

Trainings

1. Dr. P.K. Kar delivered a lecture on "Malaria and entomology under the auspices of the National Institute of Communicable Diseases Surveillance Pilot Project Training" at the Govt. Hospital, Hardwar.

2. Health Inspectors and Laboratory Technicians from State Health Department, District Hardwar were trained on microscopic examination of malaria parasites from 16-21 August 2000.

3. Mr. A.C. Pandey, Tech. Officer underwent training on vector biology and control at NICD, Delhi from 9-29 September 2000.

4. Dr. Sadhanan and his team from VCRC, Pondicherry visited from 3-8 November 2000 regarding a WHO study entitled, "Development and evaluation of DNA based probes for *Anopheles fluviatilis* complex".

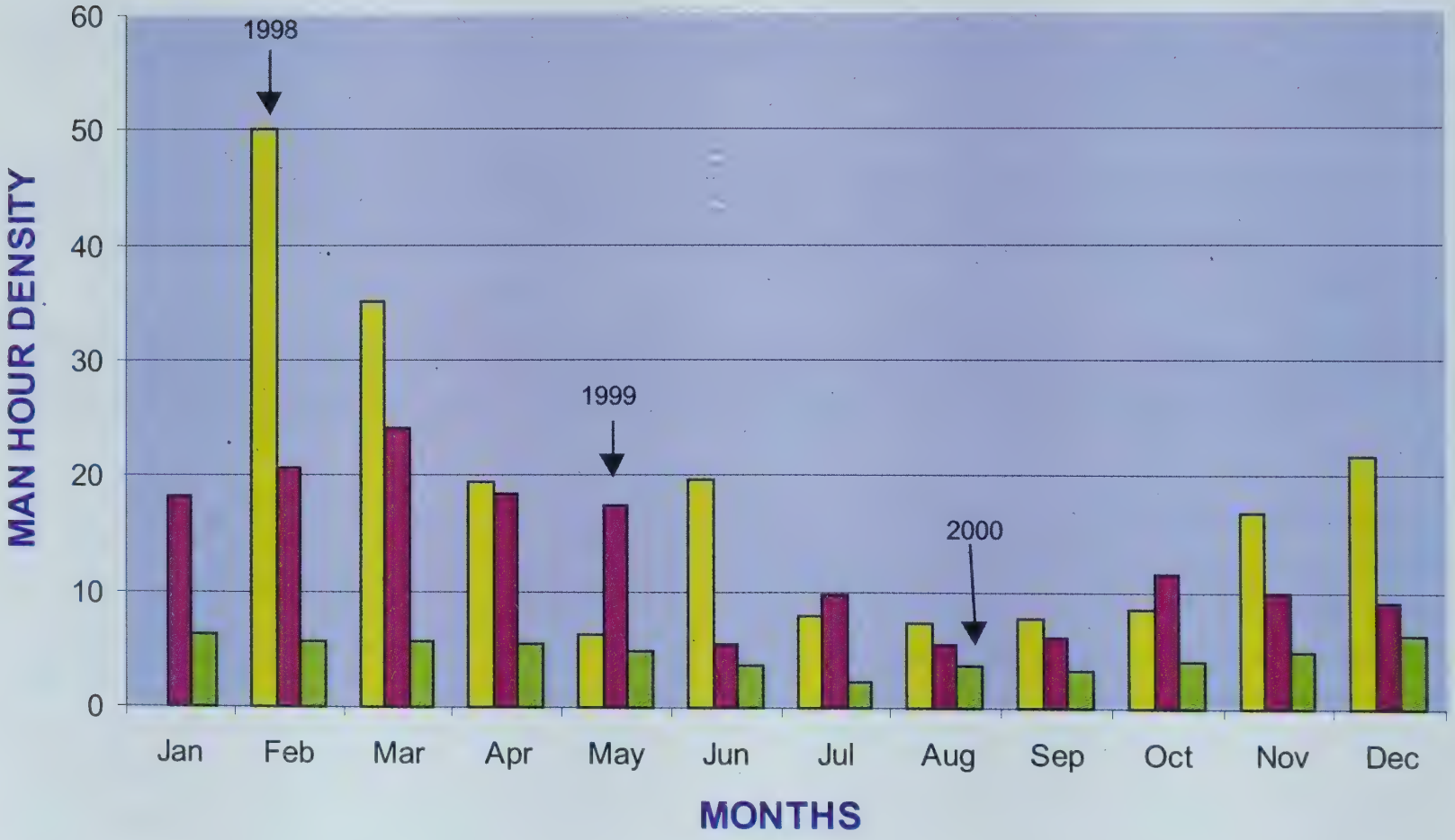
5. Dr. Khin Maune Myint, WHO fellow from Myanmar got training on "HPLC determination of antimalarials in body fluids and their applications in pharmacokinetic studies" from 13 November to 13 December 2000.

6.4 PANAJI (GOA)

Bioenvironmental control of mosquitoes in Mormugao Port Trust area in Vasco da Gama: A technology transfer project

During the year 2000, mosquito breeding sites were weekly monitored and progress of bio-engineering measures was submitted to the MPT authorities. Regular mosquito density estimation was done to assess the impact of various intervention measures. It was found that the mosquito densities declined considerably in 2000 when compared to 1998 and 1999. Four exhibitions on malaria control were held for the benefit of residential colonies. Results of opinion surveys conducted among the residents of MPT quarters and the workers in the industrial areas were analyzed and the problematic areas were identified. The action taken reports submitted by various sections of the Civil Engineering Department of MPT were analyzed and cross-checked by the spot visits. There were two joint field visits for the identification of mosquitogenic problems and to suggest appropriate corrective measures to be undertaken by the MPT Civil Engineering Department. In the month of May, progress report of the project was presented during high level meeting at MPT. Six review meetings were also held during the year to make an assessment of the progress made towards reducing mosquitogenic potential in the Port area. These meetings were attended by the MPT officials, MRC Scientists, Health Officer Vasco City and Mormugao Municipality officals.

Graph showing impact of bioenvironmental control measures on mosquito densities from 1998-2000.



Studies on the fungal associations of mosquito vectors

During this period preliminary bioassays of 91 fungal isolates were conducted against *Culex quinquefasciatus* larvae. A total of 27 isolates showed varying degree of larvicidal activity. These samples have been suitably preserved in the pure form on nutrient agar slants in the fungal culture collections of the field station. Standard bioassays of six promising fungi were conducted against *Cx. quinquefasciatus* larvae, which had shown very promising results. Spore estimation of one of these fungi was standardized by correlating NTU on Turbidometer and Haemocytometer count. Besides, 111 fungal isolates were re-cultured and maintained in sterile condition. Toxicity tests of two fungal isolates were also conducted on non-target organisms.

Malaria clinic

During this year 400 blood smears were collected in the clinic, of which 54 were positive for malaria showing slide positivity rate of 13.5 per cent. Of the positive slides, 35 were *P. vivax*, 18 were *P. falciparum* and one was mixed for both *P. vivax* and *P. falciparum*. The SfR was 4.7 per cent.

Resting behaviour and incrimination of *Anopheles stephensi* in Goa

As per the recommendation of the SAC 1999 this study was re-launched from February 2000 based on a modified protocol in which the scope of adult collection was broadened by including additional resting places in a hope to achieve better success. Fortnightly indoor collections were done in three types of human dwellings, viz. slums, traditional tiled houses and flats by the hand catch method and spray sheet method. Collections were also done outdoors. Five *An. stephensi* specimens were obtained from buildings under construction. No adult was found in the well and bush collections attempted outdoors with drop nets.

Isolation, characterization, identification, culture and testing of Bacilli pathogenic to mosquitoes in Goa – In collaboration with Goa University

Scanning microscopy of the new isolates was completed. Antibiotic sensitivity tests with all the unknown cultures were performed. SDS-PAGE analysis of two isolates and two reference strains was done and the gels were photographed. Small-scale preparation of the plasmid DNA of KSD-7 was also done. This was compared with Plasmid DNA of *Bti*. Bio-assays of KSD-4 was performed against *Cx. quinquefasciatus* larvae. The range finding bio-assays were performed with KSD-6 against *Ae. aegypti* larvae and KSD-7 against *Cx. quinquefasciatus* larvae. Main bioassays were carried out with 8 isolates, i.e. KSD1 to KSD-8 against *An. stephensi*, *Cx. quinquefasciatus* and *Ae. aegypti*. Comparative efficacy of the primary powders of KSD-4 and KSD-7 was also found out against *Cx. quinquefasciatus*, *Ae. aegypti* and *An. stephensi* larvae using doses of 4 g/l, 1 g/l, 0.5 g/l and 0.1 g/l. A negative control was also maintained with no culture added to it.

Insecticide treated mosquito net surveys : A KABP study

A KABP study was conducted on the use of mosquito nets. A pre-designed questionnaire was used to conduct the survey in different parts of Goa among 1000 families in different socio-economic strata. All

the members of 10.13 per cent families were using nets. In 8.65 per cent families few members were using net. Though nobody was using insecticide treated nets, 23.4 per cent of the people interviewed had heard about them. About 87.4 per cent among the non users showed interest in using nets in future. Further analysis of data is in progress.

Documentary on health issues related to Konkan Railways

A documentary film on Konkan Railway project on the negative and positive features of the project in the context of mosquitogenic potential was initiated with the assistance of Audio-Visual unit of the Malaria Research Centre, Delhi. The shooting will be completed in the first quarter of 2001.

Situational analysis under RBM

During the first week of November, an expert team from Delhi visited the state of Goa for analysing the malaria situation in the state in connection with inclusion of Goa under RBM. As a part of this exercise sample epidemiological surveys were conducted in five high risk areas, viz. Panaji, Aldona, Candolim, Corlim and Margao. The surveys included mosquito larval surveys, adult collections, mass blood surveys among children, fever surveys among adults and questionnaire based KAP studies on malaria among different social groups. In addition, blood samples were also collected from children for seroepidemiological studies.

Health education activities and observance of antimalaria month

The month of June was observed as antimalaria month. It consisted of talks and exhibitions on malaria and distribution of larvivorous fishes and neem saplings among general public.Dr. Ashwani Kumar delivered two lectures on mosquito control during two training programmes organized by All India Institute of Local Self Govt. at Panaji. Exhibitions were also organized for the benefit of the participants. Two talks on malaria were delivered for working women from private industrial sector which were attended by 100 women and 200 high school students. Besides, there were 11 talks and 12 exhibitions on malaria for high and higher secondary schools and the general public, which were attended by 3300 people. A health education camp consisting of lectures, exhibition and field visit was organized for 50 persons.

Social forestry work

This Centre with the help of a NGO is maintaining a nursery of neem, chhotta badam, rain tree plants and teak.

Trainings

1. Two, 3-day orientation courses on malaria microscopy were organized for eleven Lab. Technicians from the public sector, private sector and autonomous institutions for capacity building and encourage partnership during the reporting period. The training programme consisted of expert lectures, video-films and practicals.

2. A month long summer training on mosquitoes and mosquito-borne diseases was imparted to three M.Sc. Microbiology students of Goa University in May. The course consisted of lectures, demonstrations, film shows, field training, library sessions and practical training. At the end of the course, detailed reports were presented by the students.

Seminars/Conferences

1. Dr. Ashwani Kumar presented a departmental seminar on "Bioenvironmental control of malaria in Goa", which was attended by 100 researchers and students of the Department of Infectious and Tropical Diseases at the London School of Hygiene and Tropical Medicine.

2. Dr. Kumar attended the Oxford 2000 conference on challenges of parasitological diseases at the Oxford University, U.K.

6.5 BANGALORE (KARNATAKA)

Bioenvironmental control of malaria in PHC Kamasamudram, District Kolar: Study of bioenvironmental control of malaria in this PHC has been concluded. Only two vivax cases were reported from this PHC in 2000, and the API came down from 41.8 in 1993 to 0.05 in 2000.

Investigations on malaria

Entomological monitoring in PHCs Banavara and Kanakatte, District Hassan: Regular entomological surveys in these PHCs were carried out in the months of January, April, June and November. Adult emergence from the field collected larvae revealed that main breeding sites for vector mosquito *An. culicifacies* were tanks (0 to 76 per cent), wells (8 to 84.6 per cent) and stone quarries (3.6 to 20 per cent). No larvae were found where fishes were present. The man hour densities (MHD) of *An. culicifacies* varied from 2 to 24, while room densities varied from 2.5 to 13.3. In the control area MHD varied from 4.5 to 39.5. Among 189 samples of ovaries of *An. culicifacies,* there were 88 sibling species A, 62 species B and 39 remained unidentified.

In Banavara PHC, malaria is under control after the release of *Gambusia* fish. In this PHC the API came down from 154 in 1995 to 70 in 1996, 5 in 1997, 3.2 in 1998, 7.3 in 1999 and 4.1 in 2000. In PHC Kanakatte, in the fish area the API in 1995 was 77.6, 19.7 in 1996, 1.28 in 1997, 0.1 in 1998 and 0.2 in 1999. In the bednet area the API came down from 86 in 1995 to 12.2 in 1996, 0.28 in 1997, 0 in 1998 and 0.2 in 1999. In the bednet plus fish area the API came down from 187.17 in 1995 to 52.7 in 1996, 1.6 in 1997, 0.2 in 1998 and 0.2 in 1999. In the current year, an outbreak of malaria occurred in all the neighbouring PHCs of Districts Chikmagalur and Tumkur bordering PHC Kanakatte. As a result, all the bordering villages of PHC Kanakatte have been affected. Of the total 455 cases reported from this PHC, 389 cases (85.8 per cent) are from the bordering villages. It may be mentioned that all the neighbouring PHCs were sprayed with deltamethrin and cyfluthrin. A border meeting was conducted to use larvivorous fishes in all the PHCs to control malaria.

Monitoring of fish was carried out in these PHCs. A total of 85 irrigation wells, 50 step wells and 67 draw wells were checked in 36 villages. Fish were present in all except 10 step wells, 12 irrigation wells and 16 draw wells. About 2400 guppies were released into these wells. About 16,600 *Gambusia* were released in seven tanks in seven villages and four stone quarries in a village. There are sufficient fish stocks in these PHCs.

Hosur Bande, Bangalore Urban district: In Hosur Bande of District Bangalore Urban, malaria has been one of the main public health problems since 1998. Stone quarries are the main source of mosquitoes and *An. culicifacies* is the main vector. Guppy fish were released in 1998, but these could not sustain due to continuous quarrying. Out of 17 stone quarries checked, guppies were found only in four quarries. The quarry owners pump out water for quarry work which results in the depletion of fish. As a result malathion was sprayed from 1999. In March 2000 one round of malathion spraying caused drop in MHD of *An. culcifacies* (range 0.66 to 2.7). From larval samples collected from quarry pits, *An. culicifacies*, *An. subpictus* and *An. vagus* emerged. A total of 20 blood smears were collected from febrile cases and only four were positive for *P. falciparum*.

Raichur district: A follow-up study was conducted in March 2000 in two villages, Masarkal and Ramdurg, under PHCs Masarkal and Gabbur, District Raichur. Among a total of 79 slides collected from these two villages, 77 were positive for malaria (12 *P. vivax*, 64 *P. falciparum* and one mixed infection). Two rounds of malathion indoor spraying and routine fogging were carried out in Masarkal. No anopheline was available in this village, while 13 *An. culicifacies* (MHD 6.5) were collected from village Ramdurg. Malathion spray was under operation in this village.

PHCs Singetegere and Panchnalli, District Chikmagalur: A total of 751 malaria cases were reported from PHC Panchnalli (pop. 30,525) while 634 cases from PHC Singetegere (pop. 24,602). These two PHCs are stretched along borders of PHCs Banavara and Kanakatte. In these areas cyfluthrin was sprayed from 1996 to 1998. Here *An. culicifacies* is the main vector. The MHD varied from 2 to 67. Tanks (90.4 per cent), were the main contributors of *An. culicifacies* followed by wells (4.7 per cent), and bund area (4.7 per cent). Among 25 ovaries, 21 were sibling species A, two species B and two remained unidentified. Training on catching, handling, transportation and release of larvivorous fishes were rendered to seven health staff of PHCs Panchnalli, Yagachi and Singetegere of District Chikmagalur. A total of 13,000 *Gambusia* and 3,000 guppies were released in all the 13 tanks and 42 wells in six villages.

Malaria in Karkal taluk, Udupi district: In some stone quarry areas in District Udupi, a malaria survey was conducted in village Jaladhar Nagar. *An. culicifacies* was found to breed in the stone quarry pits. A total of 16 blood smears were collected; all were found positive for *P. falciparum*. Report was given to the local health department to take antimalaria measures.

Malaria outbreak investigations

Geographical reconnaissance of villages following malaria epidemic: Geographical reconnaissance was carried out in 13 villages of Districts Tumkur and Chikmagalur where recent malaria outbreak occurred. The main breeding sources of *An. culicifacies* were wells (n = 42) and tanks (n =16) followed by borrow pits (n = 2) and irrigation channels (n = 4).

C.N. Halli taluk, District Tumkur: In C.N. Halli taluk, District Tumkur an outbreak of malaria occurred during April to August 2000. A total of 3529 malaria cases were reported compared to 637 cases in 1999. An entomological survey was conducted in August. *An. culicifacies* was found to be the only vector of malaria. Adult emergence from larvae revealed that tanks (57.1 per cent) were the main contributors of *An. culicifacies* followed by wells and bund area (14.2 per cent each). About 48 ovaries were processed; of which 29 were species A, six species B and 13 unidentified. There was an unpublished report in 1988 that *An. culicifacies* was resistant to malathion in this area. Our study showed that this mosquito was highly susceptible to malathion and resistant to DDT. Training on fish work was also rendered to five staff of C.N. Halli taluk. After the training, the staff released 13,000 *Gambusia* in 13 tanks and 2750 guppies in five wells in 13 villages. These fishes were taken from PHC Kanakatte.

Roll back malaria in Tumkur district

District Tumkur of Karnataka has been selected under the WHO Roll back malaria initiative for detailed study on malaria and its suitable control measures. A situation analysis of malaria in this district was carried out in November.

Urban malaria/Vector control

Mangalore City: Control of malaria was carried out with the help of a local NGO, Jaibika Niyantrana Samiti. The larval survey showed that *An. stephensi* is the main vector and the adults were contributed by cemented tanks (37.5 per cent), overhead tank (15.6 per cent), fountains (21.9 per cent) and wells (25 per cent). *An. stephensi* in this area is found to be type form (egg ridge no varied from 18 to 22). Both guppies and *Gambusia* were used to control breeding. Fishes released earlier are surviving well. A total of 1572 malaria cases were reported from this City in 2000.

Bangalore City: Mosquito nuisance is severe in Bangalore City. Recently constituted Bangalore Agenda Task Force (BATF) has initiated 'Swachha Bangalore' programme to keep Bangalore City clean and mosquito free. The mosquito control programme will be carried out with the help of Bangalore City Corporation and BATF. As requested by the corporation, training to the health personnel engaged on mosquito control was imparted to 11 Insect Collectors, 20 Head Gangmen and 234 Gangmen and ALOs.

Blood meal analysis of *An. culicifacies* and *An. fluviatilis*

In this quarter a total of 579 blood meals of *An. culicifacies* were analysed; two were positive for human and 337 bovine (AI 0.35 per cent). Likewise, 101 blood meals of *An. fluviatilis* were processed; no sample was found positive for human.

Malaria clinic

A total of 132 blood smears were checked in the malaria clinic, of which eight were positive for malaria including seven *P. falciparum* and one *P. vivax* cases.

Observation of antimalaria month in June 2000

To observe antimalaria month, staff of the field station participated in various activities. A team of MRC participated in a state level inter-departmental coordination meeting on malaria at Bangalore. About 200 participants attended the meeting. In Hosur Bande area, District Bangalore, a one-day antimalaria meeting was organised along with State and Central Health Departments. Members from Zila Parishad, Gram Panchyat, local NGO and about 150 villagers participated in this meeting. Need for community action for the control of malaria was emphasised. Similar meeting was organised in taluk health office in Gudibande in District Kolar. About 200 people took part in this meeting. Dr. T.S. Sathyanarayan participated in malaria workshop for local RMPs conducted by a local NGO (VHAK) at PHC Sindanur, District Gulburga. Health camps highlighting all activities of MRC were organised in these meetings.

Conferences/Meetings/Other activities

1. Dr. S.K. Ghosh attended a 3-day WHO workshop on Roll Back Malaria from 3-5 January in Chandigarh.

2. Dr. S.K.Ghosh attended the V International Symposium on Vectors and Vector-borne Diseases held at the Punjabi University, Patiala from 16-18 February and presented a paper on Malaria in tank based village ecosystem in Karnataka.

3. Dr. S.K. Ghosh attended Intercountry workshop on cross-border issues in malaria, kala-azar and Japanese encephalitis: prevention and control at Vector Borne Disease Research and Training Centre, Hetauda, Nepal from 24-28 July 2000.

4. Dr. S.K. Ghosh and Dr. T.R.R. Sampath attended National symposium on recent trends in combating mosquitoes held at Loyola College, Chennai on 3-4 October 2000. They presented papers on 'Selective vector control of malaria in a dry zone ecosystem of south India' and 'Use of pyrethroid treated bednets in malaria control in Orissa, India' respectively.

5. Dr. S.K. Ghosh attended National Workshop on Communicable Diseases held at Hyderabad from 15-16 December.

6. Dr. S.K. Ghosh delivered a lecture on vectors of malaria in a training programme at Department of Parasitology, University of Agricultural Sciences, Bangalore.

7. Dr. S.K. Ghosh, Dr. S.N. Tiwari, Dr. A.K. Kulshrestha, Dr. T.S. Sathyanarayan and Sh. R.R. Sampath attended a one-day workshop on Elimination of filariasis in Karnataka at Bangalore on 31 January 2000. This was organised by CHC and VCRC, Pondicherry.

8. A 2-day workshop on malaria for school teachers was organised by the local NGO, Malaria Jaivika Niyantrana Samiti, Mangalore. MRC participated in the workshop. About 35 school teachers were present in this workshop.

9. Dr. S.K. Ghosh attended a meeting on bioenvironmental control of malaria. This was organised by the Task Force on Health and Family Welfare, Govt. of Karnataka.

10. Prof. G. Padmanaban of Indian Institute of Sciences, Bangalore visited the PHC Kamasamudram, District Kolar to see the work of bioenvironmental control of malaria. He appreciated the measures taken by MRC.

11. Dr. S.K. Ghosh attended Inter-district border meeting on malaria held at Kemangundi, District Chikmagalur. Health officials from four districts, viz. Hassan, Chitradurga, Chikmagalur and Tumkur attended the meeting. Since there were recent malaria outbreaks in Tumkur after the use of synthetic pyrethroids, decision was taken to use larvivorous fish for the malaria control.

12. Scientists of MRC visited problematic PHCs of Districts Tumkur and Chikmagalur along with Joint Director (M&F), State Health Department. It was decided to use larvivorous fishes in all the problematic PHCs in Districts Tumkur, Hassan, Chikmagalur and Chitradurga.

13. One meeting on bioenvironmental control of malaria was organised by DMO, Chikmagalur at Taluk Health Office, Kadur. All Medical Officers and Health Inspectors of taluks Kadur and Tarikere attended the meeting.

14. Dr. S.K. Ghosh and Dr. S.N. Tiwari attended a meeting of PHC Medical Officers at the Taluk Hospital, Arsikere on 5 October 2000. They discussed on the bioenvironmental control of malaria in Arsikere taluk.

15. Dr. S.K. Ghosh and Dr. S.N. Tiwari took part in a training programme on vector-borne diseases for trainers of Institute of Vector Control and Zoonoses, Hosur, T.N. at MRC, Bangalore on 9 December 2000.

16. A one-day training on different aspects of malaria was given to 24 students of a local Medical College.

6.6 SONAPUR (ASSAM)

Monitoring of multi-drug resistant malaria in the north-eastern India

The purpose of the study was to ascertain the therapeutic efficacy of different antimalarials for the treatment of uncomplicated *P. falciparum* malaria and to help facilitate updating the existing national drug policy. A malaria clinic was established during June/July 2000 in Kumarikata, District Nalbari along the Assam-Bhutan border in collaboration with MADEP (NGO). Among 1116 patients reporting fever, 437 (39 per cent) were malaria positive, and of these 80 per cent were *P. falciparum* cases. Malaria positive cases were detected in all age groups including infants supporting active transmission of the disease. Among *P. falciparum* positive cases, 13 patients volunteered for follow-up investigations to test the therapeutic efficacy of antimalarials including chloroquine, sulfadoxine-pyrimethamine (SP) compound and quinine (parenteral) in the given order. On extended follow-up investigations (Day 0, 1, 2, 3, 7, 14, 21 and 28), it was observed that eight cases (6196) were sensitive to standard regimen of chloroquine and the remaining five cases (39 per cent) exhibited late treatment failure (LTP). Of these five cases, one case (44/M) opted out and the remaining four were administered SP compound at the prescribed dose. Among these, three (75 per cent) subjects were sensitive and one case was categorized as early treatment failure (ETF). The latter was treated with quinine (parenteral) and was cured of the malarial infection. During the period under review, a progress to date was presented in SAC- 2000, and since then five additional cases have been enrolled and continuing.

Clinical trials of azithromycin

This was a randomized and double blind comparative study of azithromycin vs chloroquine for the treatment of *P. falciparum* and *P. vivax* malaria sponsored by M/s. Pfizer Ltd. During the period under review, the study was restricted for the treatment of *P. vivax* malaria, and 36 subjects were contributed from this site for follow-up investigations. Our role was restricted to initial selection of the patient and the subsequent follow up for parasitological monitoring. Clinicians from Guwahati Medical College evaluated the clinical parameters. This being a multicentric study, a total of 200 subjects were enrolled from six sites and the data were analysed by the sponsorer. Based on meta-analysis, it was concluded that chloroquine results in faster resolution of parasitaemia and symptoms than treatment with azithromycin. However, treatment with chloroquine is associated with more side-effects than azithromycin, and the latter could be considered as second line of treatment for vivax malaria. Nevertheless, the antimalarial activity of the azithromycin molecule has been clearly demonstrated. It is now proposed to conduct combination therapy involving azithromycin + chloroquine for the treatment of *P. falciparum* malaria.

Evaluation of rapid diagnostic test kit

The development of rapid malaria test kits is a welcome development to ensure early case detection and treatment particularly in the remote inaccessible areas. In the period under review, DiaMed OptiMAL Rapid Malaria test was field evaluated in the malaria endemic villages of Kamrup district, Assam. This test kit is based on the detection of parasite specific *Plasmodium* lactate dehydrogenase, and is used for the detection of both the parasite species, i.e. *P. falciparum* and *P. vivax*. A high degree of correlation was observed using microscope and the kit among 144 clinical malaria cases particularly for *P. vivax*

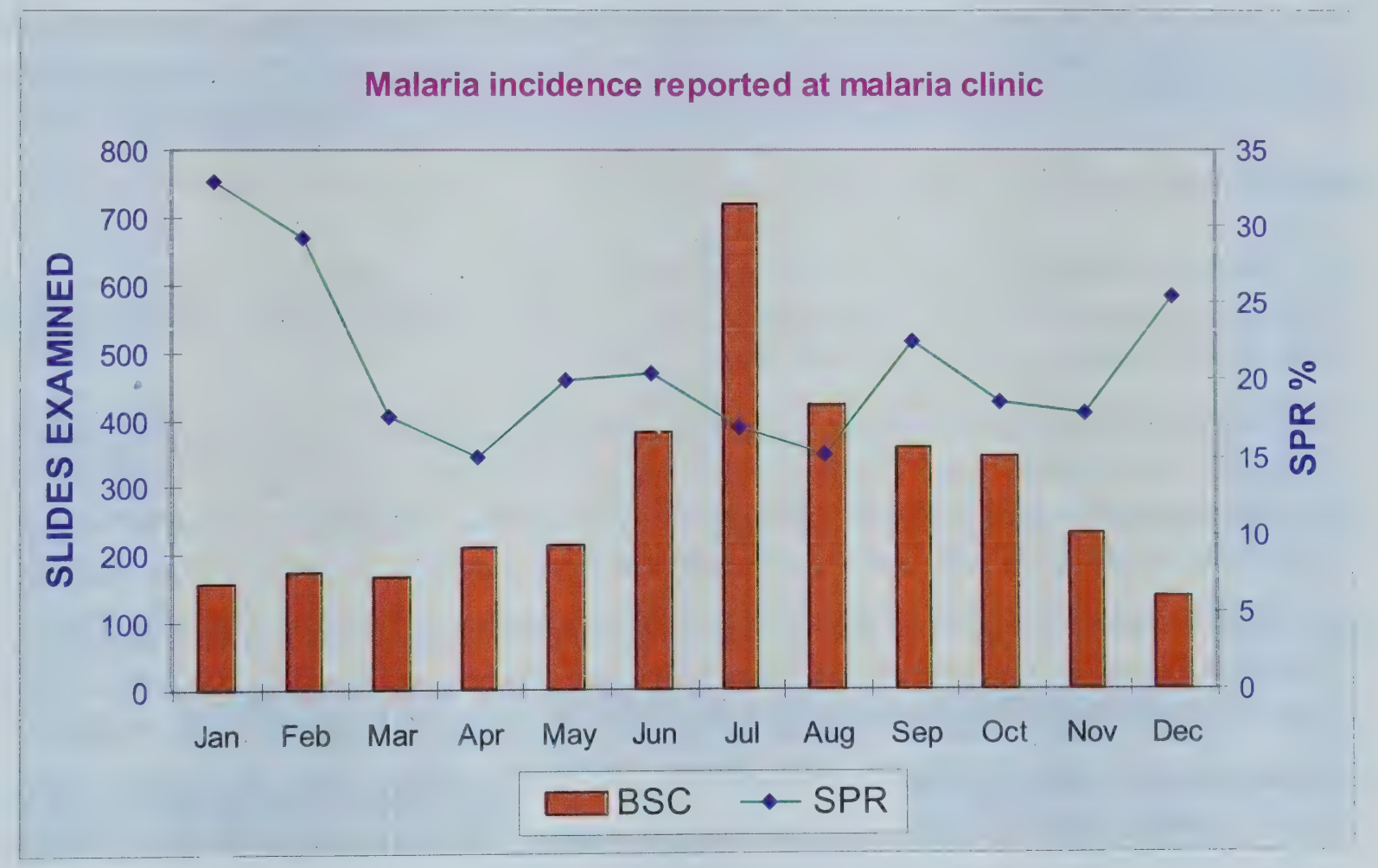
infections. However, in *P. falciparum* cases, the intensity of band was comparatively less marked and nearly 20 per cent of the cases were disconcordant between the two methods. The time taken for the test procedure was from 15 to 20 min. The test procedure was simple and could be performed by a field worker with minimal training. The kit was found to be useful for on the spot diagnosis of malaria cases.

Situational analysis under roll back malaria (RBM) initiative

Under RBM initiative of WHO (SEARO) region, Dr. Vas Dev participated in the meeting held in Delhi on 5 October 2000. The situation analysis of the Aizwal district in Mizoram was conducted during 31 October to10 November 2000. A team consisting of scientists from MRC, NAMP and this field station carried out the survey in close coordination with the Mizoram State Health Directorate. It is proposed to carry out in-depth analyses on the epidemiology of the disease to determine the true burden associated with malaria.

Malaria clinic

A malaria clinic is being run in Sonapur PHC (Dimoria Block) to ensure early case detection and prompt treatment of the patients. Of the 3518 blood smears collected during 2000 from patients reporting fever, 693 (19.69 per cent) were malaria positive. A sudden increase in number of malaria cases was observed in the month of July associated with nearly two fold increase in *P. falciparum* infections. Between July



and December, the proportion of *P. falciparum* ranged from 64 to 80 per cent. The high proportion of *P. falciparum* cases in the months of November and December is somewhat unusual trend not witnessed in the past decade, and is the subject for further analyses in relation to meteorological profile. Overall, as compared to the preceding year, this year morbidity associated with malaria was much less. This could

be attributed due to drug pressure and DDT focal sprays consequent to malaria outbreak in the year 1999. These antimalarial measures were indeed effective as reflected in the drastic reduction in proportion of *P. falciparum* cases by nearly 20 to 30 per cent. The same phenomenon was observed in the year 1996 following malaria outbreak in 1995.

Bednet response survey (KAP Study)

A survey was conducted in malaria endemic villages of Sonapur PHC (Kamrup district) to determine washing frequency of mosquito nets while in use and other behavioural aspects. Total number of respondents were 236, which comprised men and women of different ethnic groups. It was observed that 52 per cent of respondents washed the nets at quarterly intervals, 43 per cent at monthly intervals and only five per cent on half yearly intervals. Over 90 per cent of the respondents preferred nylon to cotton fibre, and the preference for treated vs. untreated nets was 50:50. Over 75 per cent of the respondents stated that the durability of nets in use was over two years, while the remaining reported average life of nets of one to two years. Most people (90 per cent) slept indoors while the remaining slept outdoors either in the open courtyard or in Jhum huts in the paddy field.

Promotion of biocontrol methods

During this period, 8000 larvivorous guppy fish were provided to CRPF and Air Force Cantonment areas on the request of the management. These fishes were introduced in the open drains and water bodies to combat mosquito menace. There has been a great relief from mosquito nuisance in the target areas.

Seminars/Workshops attended and papers contributed

1. Dr. Vas Dev participated in the XIV National Congress of Parasitoiogy held at ICGEB, New Delhi during 23-26 April 2000 and contributed a poster on "Malaria outbreak in Assam, an investigation" and also co-chaired a session on Vector Biology and Control.

2. Dr. Vas Dev participated in the workshop on "Entomological surveillance and control of vector-borne diseases" held at the National Institute of Communicable Diseases, Delhi from 17- 20, July 2000 sponsored by WHO (SEARO). Dr. Vas Dev chaired one of the academic sessions to formulate guidelines for short/long-term vector control measures for malaria, JE, Dengue/DHF and Kala-azar.

3. Dr. Vas Dev delivered a lecture on "Malaria and its containment", at the Continuing Medical Education meeting held at Dirlal Central Hospital, Distt. Dibrugarh (Assam) on 12 August 2000 sponsored by Assam Branch Indian Tea Association (ABITA).

4. Dr. Vas Dev attended the tea gardens Medical Officers meet organized by Indian Tea Association held on 23 September 2000 in Tezpur. A lecture was delivered on "Malaria control with special focus on immuno-diagnostics to ensure early case detection and prompt treatment in order to decrease morbidity and mortality associated with the disease".

5. Mr. S. Phookan, ARS, participated in the workshop on Malaria control in Assam organized by MSF, Holland (NGO) held at Guwahati during 28-29 November 2000.

6. Dr. Vas Dev was invited to participate in the scientific session on malaria in XXV Assam State Medical Conference (Medimeet 2000) held at Guwahati during 16-17 December 2000.

Distinguished visitors at the field station

1. The Commanding Officer, Air Force Station, Digaru visited MRC on 12 May 2000. He was apprised of MRC activities, various study projects underway and highlights of work done at the station.
2. The Commanding Officer, 51, ASP, Digaru visited MRC on 16 October 2000. He was apprised of MRC activities in the N.E. region and its achivements. An exhibition on malaria was displayed.

Trainings

1. Training on malaria microscopy for Assam State Laboratory Technicians (Induction level), 24 January to 5 February at Sonapur sponsored by EMCP project.
2. Re-orientation training on malaria microscopy for Assam State Laboratory Technicians, 7-11 February at Sonapur sponsored by EMCP project.
3. Training course on malaria for MPWs/DDCs/FTDs and Community Health Volunteers, 23-24 March at Borborah (Dibrugarh) sponsored by EMCP project.
4. Training camp on malaria microscopy for rural volunteers (Induction level), 19-30 May at Akajan (Dhemaji district), organized by Rural Volunteer Centre (NGO).
5. Training on malaria microscopy for technicians of tea garden hospitals (Refresher course), 17-18 November at Dibrugarh organized by Assam Branch Indian Tea Association.

Health education and extension work

1. Lecture on insecticide treated mosquito nets (ITMNs) and demonstration on 11 January at Regional Training Centre, Shillong.
2. Demonstration on malaria microscopy and ITMNs on 13 January at Regional Directorate, GOI, Shillong.
3. Health education and demonstration on ITMNs, 23 January at TAGs NGO, Jamuguri (District Nalbari).
4. Lecture on Malaria and its control on 25 January at Regional Nursing College, Sonapur.
5. Malaria awareness camp and demonstration on ITMNs on 5-6 Febuary at NECHA (NGO), Ambagan (District Darrang).
6. Malaria awareness and case detection camp on 6 February at TAGs(NGO), Chechapani (District Nalbari).
7. Exhibition on bioenvironmental control of malaria on 12 Febraury at Sonapur Girls High School, Sonapur.

8. Lecture on malaria and its control methods, 17 Febuary at Indian Institute of Enterpreneurship, VHAI, Assam NGO.

9. Demonstration on insecticide treated nets and fever survey on 27 February at MADEP(NGO), Kawli (District Nalbari).

10. Exhibition on bioenvironmental control of malaria on 2 March at CRPF, Noonmati, Guwahati.

11. Health camp and fever survey on 8 March at NECHA (NGO), Baghty, Nagaland.

12. Lecture on drug sensitivity status of antimalarials in *P. falciparum* malaria in N.E. Region on 16 March at Regional Directorate (H & FW), Sonapur.

13. Demonstration on ITMNs and fever survey on 26 March at MADEP (NGO), Kamarkuchi (District Nalbari).

14. Demonstration on ITMNs and fever survey on 23 April at MADEP (NGO), Kawli (District Nalbari).

15. Lecture on malaria and its control and demonstration on ITMNs on 25 April for CRPF at MRC, Sonapur.

16. Malaria awareness camp on 26 May at MADEP (NGO), Kumarikata (District Nalbari).

17. Lecture on ITMNs on 23 May at CRPF, Rani (District Kamrup).

18. Lecture-cum-demonstration on ITMNs on 6 June For VHAI at MRC, Sonapur.

19. Health camp and awareness programme on 15 June at SAT(NGO), Khetri (District Kamrup).

20. Lecture on antimalarials and demonstration on ITMNs on 6 July for CRPF at MRC, Sonapur.

21. Demonstration on ITMNs and lecture on malaria control on 7 July at CRPF, Base Hospital, Guwahati.

22. Lecture on malaria and its control and demonstration on malaria microscopy on 7 August for Regional Nursing College, Guwahati at MRC, Sonapur.

23. An exhibition on malaria held on 7-9 August at Kendriya Vidyalaya, Digaru.

24. Lecture on malaria and its control and demonstration on bednets on 8 August for CRPF at MRC, Sonapur.

25. Malaria awareness camp and fever survey on 18 August at World Vision India (NGO), Badagaon (District Kamrup).

26. Malaria awarness camp and fever survey on 21 August at World Vision India (NGO), Dhorbam (District Kamrup).

27. Health camp and fever survey on 27 August at Upkar (NGO), Kahikuchi (District Kamrup).

28. Exhibition on malaria on 1 Sepember at Kendriya Vidyalaya, Digaru.

29. Health camp and fever survey on 11 September at CRPF, Morigaon.

30. Lecture on malaria and its control and practical demonstration on malaria microscopy on 12 September for Regional Nursing College, Guwahati at MRC, Sonapur.

31. Health Camp and fever Survey on 12 September at MADEP (NGO), Angrakata (District Nalbari).

32. Lecture on malaria and its control and demonstration on ITMNs on 24 October organized by Air Force Working Woman Association, Digaru.

33. Malaria microscopy and biological control method on malaria control on 14 November for CRPF at MRC, Sonapur.

34. Lecture on treatment, prevention and control aspects and demonstration on ITMNs on 20 November for Meghalaya Police and CRPF at MRC, Sonapur.

35. Lecture on life cycle of malaria parasite and general awareness on diseases on 22 November for CRPF at MRC, Sonapur.

6.7 HALDWANI (UTTARANCHAL)

Malariogenic stratification of Districts Nainital and Udham Singh Nagar for malaria control

For the last ten years, declining trend of malaria was reported in all PHCs of both the districts but few PHCs in terai and bhabar (fringe and deep forest areas) of Udham Singh Nagar and Nainital districts are experiencing high malaria. For the application of appropriate control methodology in such areas, data on various epidemiological parameters, viz. topography, vector prevalence, average annual parasite incidence (API) and average slide positivity rate (SPR), epidemic potential (highest value of API) were collected from DMO, Udham Singh Nagar. The data on average annual rainfall for the last five years were collected from various agencies of the districts. To know the prevalence of malaria vectors, mosquitoes were collected randomly from one village of each PHC of both the districts. Information on the above five variables was compiled and the cumulative weightage were recorded to know the malaria risk PHCs in both the districts. The highest weightage was recorded in Gadarpur (31) followed by Belparao (30), Kelakhera (29), Mota Haldu (29), Kotabagh (21), Sitarganj (21), Khatema (21), Kichha (17), Jaspur (17), Bhimtal (14), Betalghat (10), Okhalkanda (8) and Ramgarh (6).

The cumulative weight range was divided into five strata, i.e. 0 to 10 (stratum I), 10.1 to 15 (stratum II), 15.1 to 20 (stratum III) and 20.1 to 25 (stratum IV) and 25.1 to above (stratum V) from low to very high malaria risk PHCs. The findings thus revealed that Betalghat, Ramgarh and Okhalkanda in hills are showing low malariogenic potential, low incidence and low epidemic potential. Bhimtal in hills is showing low malariogenic potential and low incidence and low to moderate epidemic potential. Jaspur and Kichha in terai have moderate malariogenic potential, moderate to high incidence and moderate epidemic potential. Kotabagh in bhabar and Sitarganj and Khatema in terai showed high malariogenic potential and moderate to high incidence. Gadarpur and Kela Khera in terai and Belparao and Mota Haldu in bhabar showed high malariogenic potential and high to very high incidence.

Malaria epidemic investigation in Moradabad district

During the months of September and October 2000, investigations on malaria epidemic were carried out in four highly affected villages, viz. Hamirpur, Nakatpuri, Lakhanpur and Rahmat Nagar of Bhojpur PHC, District Moradabad. Various entomological observations, viz. larval collection and adult emergence, vector density, abdominal conditions, vector incrimination, parous rate of *An. culicifacies*, outdoor and indoor night bait collections, adult susceptibility test, parasitological surveys, and spleen surveys were conducted.

Entomological: During the period a high number of larvae and pupae were collected from different breeding grounds. The highest (2.1) density per dip of III instar larvae was recorded in tube well pits followed by paddy fields (0.8), drains (0.8), tyre/hoof prints (0.3) and ponds (0.03). The pupal density was recorded in tyre/hoof prints (0.2), followed by paddy fields (0.1), drains (0.1) and tube well pits (0.1). The breeding percentages in fields were: *An. subpictus* 70 per cent, *An. culicifacies* 20 per cent, *An. annularis* 10 per cent in paddy fields; *An. subpictus* 12 per cent, *An. nigerrimus* 24 per cent, *An. vagus* 44 per cent, *An. barbirsotris* 20 per cent in drain; whereas in tube wells the breeding percentage of *An. nigerrimus* was cent per cent.

A total of five anophelines species, viz. *An. culicifacies*, *An. aconitus*, *An. annularis*, *An. subpictus* and *An. vagus* were collected during morning hand collections. The average per man hour density was 7, 1, 0.5, 26 and 14, respectively. In cattlesheds, anopheline density was higher than human dwellings. To know the gonotrophic conditions of the vector species, a total of 90 *An. culicifacies* females were examined. The proportions of unfed, fully fed, semigravid and gravid specimens of *An. culicifacies* were 3.3, 12.2, 46.7 and 37.8, respectively. This revealed endophilic behaviour of the vector species. A total of 30 specimens of *An. culicifacies* were dissected which revealed 56.8 per cent parous rate.

During night (1800 to 0600 hrs) the indoor and outdoor mosquito collections were made on human baits. Four mosquito species, i.e. *An. culicifacies*, *Cx. quinquefasciatus, Cx. tritaeniorhynchus* and *Cx. whitmorei* were recorded. The average per night per bait biting indoors and outdoors was 10 and 12 of *Cx. quinquefasciatus,* two and four of *Cx. tritaeniorhynchus;* nil and three of *Cx. whitmorei* and nil and two of *An. culicifacies,* respectively.

A total of 351 female specimens of *An. culicifacies* collected from four malaria affected villages were dissected for sporozoites infection but none was found positive for sporozoites.

Tests were conducted using impregnated papers of DDT (4 per cent), malathion (5 per cent) and deltamethrin (0.05 per cent) and the results revealed 42.5 per cent, 86.7 per cent and cent per cent mortality of *An. culicifacies* respectively.

Parasitological: Blood smears were collected by mass and active fever surveys in epidemic affected villages of Moradabad district, and by mass blood survey in Hamirpur, the worst affected village. Out of a total of 463 blood slides collected, the SPR and SfR were 59.6 and 56.8 per cent, respectively. The active fever survey conducted in three other affected villages revealed SPR and SfR of 86.7 and 81 per cent, respectively. The spleen rate among the children aged between two and nine years was found 44.2 per cent thereby showing high endemicity of malaria in these villages.

Causes of malaria epidemic: Main causes of malaria epidemic in above villages of Bhojpur PHC included poor or no surveillance, no insecticide residual spraying, high incidence of *P. falciparum* malaria and favourable mosquitogenic conditions.

Mosquito breeding source surveys for biocide trial

For the field trials of *Bacillus thuringiensis israelensis* extensive surveys for mosquito breeding potentials were made in December 2000. The localities surveyed for this purpose were Haripur Jaman Singh, Lalmani Newar, Chhattarpur, Kali Nagar, Kulha Hemlata, Lal Kuan, Nagala, Pant Nagar, Sainik Farm, Patthar Chatta, Deval-Chaur, Daharia, Mukhani, Dhampur and Anandpur. The surveys revealed mosquito breeding in pokhars of Dhampur and Anandpur villages whereas borrowpits in roadside and roadway tracks supported mosquito breeding in other villages despite low temperature during December.

Seroepidemiological investigation

From three villages, i.e. Kishanpur, Ghurdawar, Devalchaur and Haripur Motia, a total of 111 blood slides and filter paper strips were prepared and sent for detailed serological study at MRC, HQs, Delhi.

Sibling species study

A total of 63 ovaries pulled from *An. fluviatilis* collected from village Tilpuri (terai) were sent to MRC, HQs, Delhi for sibling species complex study.

Insecticide susceptibility test

Susceptibility tests using impregrated papers of different insecticides, i.e. malathion (5 per cent), deltamethrin and lambdacyhalothrin (0.05 per cent), were conducted against *An. culicifacies* and *An. vagus*. *An. culicifacies* was 86.2 per cent susceptible to malathion and fully susceptible to deltamethrin and lambdacyhalothrin. *An. vagus* was completely resistant to DDT (4 per cent) but fully susceptible to these insecticides.

Malaria clinic

A total of 556 blood smears of fever patients attending the clinic were examined, of which there were 78 cases of malaria (42 *P. vivax,* 35 *P. falciparum* and one mixed *Pf* + *Pv*). The cases were given antimalarial treatment.

Health education and antimalaria month

Antimalaria activities were carried out during June 2000, which was observed as antimalaria month. Health education and demonstrations were given to the public on malaria transmission, its prevention and control. Contacts with the communities were made through door-to-door and group meetings. A total of 196 meetings, three health camps and two demonstation camps were organized where more than 2800 people attended. Pamphlets, folders, cards related to malaria and its control methods were distributed in urban and various villages. Blood smears were also prepared from fever patients during the above awareness programme.

Trainings

1. About 21 participants of malaria entomologists/biologists participated in the training programme organized jointly by MRC/NAMP, Delhi from 11 to 15 February 2000.
2. Four persons from VCRC Pondicherry visited the field station from 8-13 November 2000 for cytological activities.
3. Two technicians from Mehta Charitable Trust Haldwani underwent malaria training from 14-16 March 2000.
4. A technician from Peerumadara PHC, Nainital underwent malaria training from 26 July 8 August 2000.

Conferences/Symposia/Meetings attended

Dr. R.P. Shukla and Dr. S.N. Sharma participated in the following activities:

1. V International Symposium on Vectors and Vector-borne Diseases held at Punjabi University, Patiala (Punjab) from 16-18 February 2000.

2. XIV National Congress of Parasitology held at ICGEB, New Delhi from 23-26 April 2000 and presented papers on "KAP study on malaria in forest and non-forest areas of District Nainital, U.P." and "Seasonal prevalence of anophelines in the Kumaon foothill region of Nainital district, Uttaranchal".

3. Dr. R.P. Shukla attended a block level meeting organized by DMO, Rudrapur and delivered a lecture on Malaria in terai and methods of control.

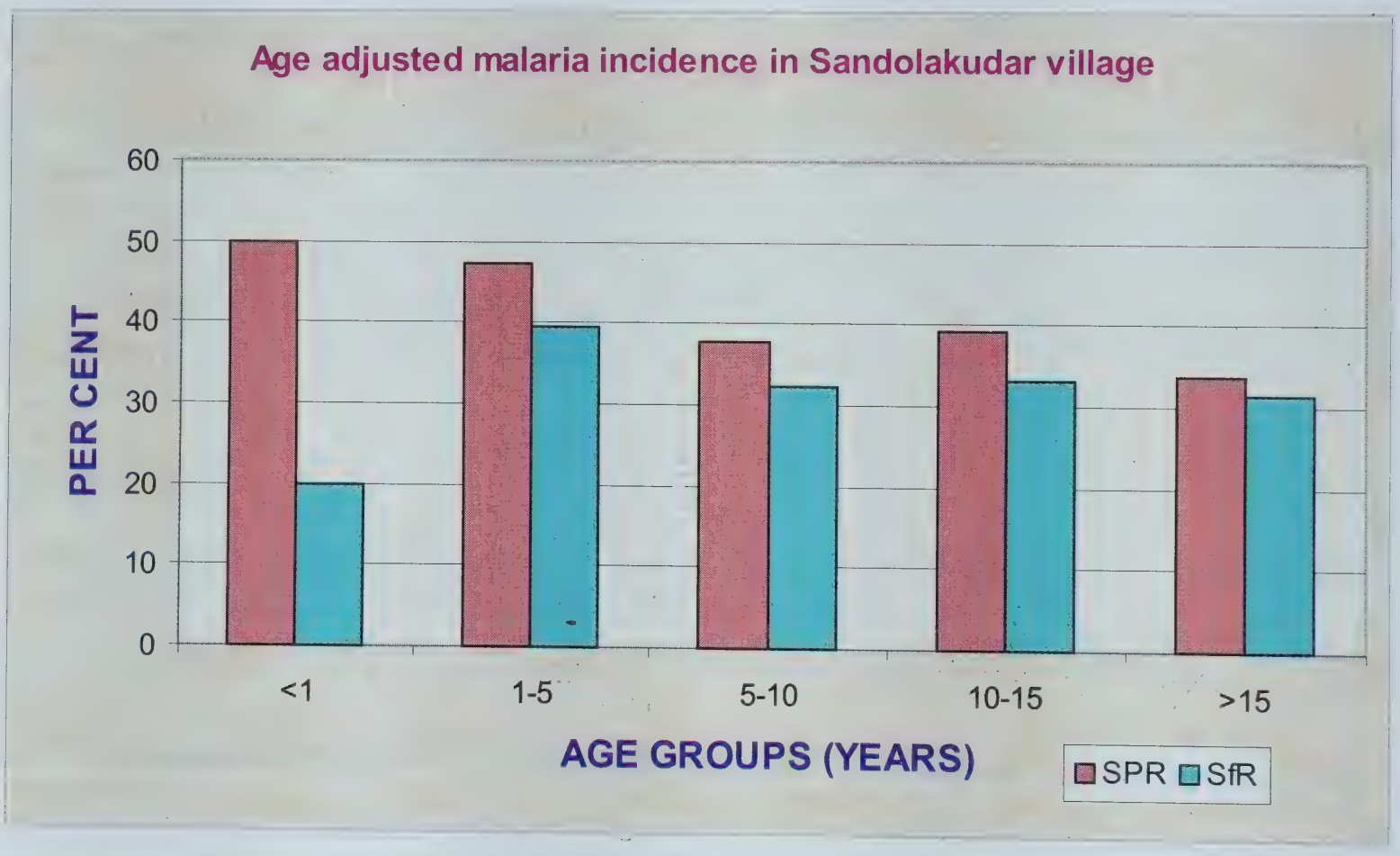
4. Dr. R.P. Shukla attended meetings at Rotary Club, Haldwani in collaboration with IMA on 28 May and 18 June 2000 and delivered lectures on "Prevention and treatment of malaria" and "Awareness in community on malaria", respectively.

6.8 ROURKELA (ORISSA)

Development of a site for malaria vaccine trial (A collaborative project with International Centre for Genetic Engineering & Biotechnology, New Delhi funded by Deptt. of Biotechnology, Govt. of India)

Studies were initiated in a hyperendemic and low endemic areas of Sundargarh district, Orissa for preparation of site for malaria vaccine trial. On the basis of preliminary parasitological and entomological surveys, the following two sets of villages under Gurundia and Birkera PHCs of Sundargarh district were:

High incidence villages: These constitute a group of eight villages with a total population of 2058, are located in deep forests close to the streams, under the influence of *An. fluviatilis*, and have persistent malaria transmission. These villages are Tamra, Jagada, Pandripathar, Chirobeda, Bagiakucha and Benuam under Gurundia PHC; Rangamati and San Dolakudar under Birkera PHC. The villages are approachable round the year.



Low incidence villages: Five villages, viz. Sarla, Mahaliapally, Malalickpally, Chikatmati and Bhalupatra with a total population of 2163 under Birkera PHC, situated in a plain area close to a perennial river are under the influence of *An. culicifacies*. The malaria transmission is seasonal and is at a low level.

Tribals predominantly inhabit the study villages. There are eleven recognised tribal communities out of which Oram, Munda and Khadia are predominant. Male and female population in the study villages are 51 and 49 per cent respectively and the literacy rate is 47.6 per cent. The villages represent low socio-economic status of the people and majority of the villagers are subsistence farmers.

The census operation in the study villages was completed and the geographical reconnaissance and mapping of villages for GIS data base is in progress. After finalization of study villages, regular surveys were initiated from the month of August. Active case detection at weekly interval through village volunteer workers was initiated in all the study villages. The SPR, SfR, *Pf* per cent and parasite index (PI) in the forest villages were 41.8, 35.9, 85.9 and 231.3, respectively, whereas in the plain area villages these were 35.7, 23.8, 66.6 and 90.1, respectively. The malaria incidence was more in the younger age groups up to 15 years in the forest area but in the plain area malaria cases were evenly distributed in all the age groups. The infant parasite rate (IPR) in the forest area between August to December was in the range of 60 to 90 per cent, whereas in the plain area IPR was nil during August to November and it was cent per cent in the month of December.

The first quarterly parasitological and entomological surveys were conducted in the month of September. Mass blood surveys and general health checkup camps were organised in all the study villages. About 40 per cent of the total population was screened for malaria parasites. In the forest area, the SPR, *Pf* per cent and PI were 21.1, 83.3, 84.55 respectively, whereas in the plain area villages the SPR, *Pf* per cent and PI were 2.5 , 70 and 9.25 respectively. The second quarterly mass blood survey was conducted in the month of December during which 1773 blood slides were collected from the forest area and the plain area villages. The SPR, *Pf* per cent and PI in the forest area villages were 20.8, 80.3 and 93.8 respectively, whereas in the plain area villages these were 4.6, 82.1 and 18 respectively.

Spleen surveys among children (2 to 9 years) and adults were carried out in the study villages during September and December. In the forest area, the child spleen rate (CSR) during September and December was found to be 77.4 and 70.3 and the adult spleen rate (ASR) was 31.6 and 26.3 respectively. In the plain area the CSR during September and December were 34.6, 44.9 and the ASR were 9.9 and 7.4 per cent respectively. The study showed that villages situated in the forest area are hyperendemic.

For entomological surveys, two indicator villages each in the forest and plain area were selected and longitudinal and quarterly surveys were carried out. About 15 anopheline species from forest area and nine species from plain area were recorded, out of which *An. culicifacies* was widely prevalent in both the areas. *An. fluviatilis* was altogether absent in the plain area. The man hour density of *An. culicifacies* in the forest and plain area was in the range of 5.2 to 39.5 and 9.7 to 25.5, respectively. The MHD of *An. fluviatilis* in the forest area ranged from 6.3 to 26. In the forest area, the man biting rate (MBR) of *An. culicifacies* during September and December was nil but in the plain area it was nil and one, respectively. The MBR of *An. fluviatilis* in the forest area during September and December was 23.9 and 6.2, respectively and it was nil in plain area. Further studies are in progress.

Malaria transmission dynamics and field studies on *P. falciparum* in a tribal area

The study was continued as part of a collaborative project with Ispat General Hospital, Rourkela and International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi. Malaria incidence data were collected through weekly active surveillance. During the year, 848 blood slides were collected and examined, out of which 322 were found positive for malaria (*Pv* 42, *Pf* 277, Mixed 3). The slide positivity rate and the slide falciparum rate were 38 and 33 per cent, respectively and *Pf* per cent was 87. The annual parasite index was 1219.7. Malaria cases were recorded throughout the year but the peak was observed between October and December. The incidence of malaria was more common in younger

age groups of up to 15 years. The infant parasite rate was cent per cent between the month of November and March. The child parasite rate was constantly high during all the months with an average of 42.2 per cent. During the year, mass blood surveys were carried out in the month of May, September and December to know the malaria prevalence in different transmission seasons. Out of 305 blood slides collected, 50 were positive (*Pv* 7, *Pf* 41, *Pm* 1, Mixed 1) and the parasite rate was found to be 16.4 and *Pf* per cent was 84. Majority of the malaria cases were asymptomatic. The average enlarged spleen in children and adults was 1.73 and 1.54, respectively thereby showing that the area is hyperendemic for malaria.

About 15 anopheline species were recorded from the study area but the two malaria vectors species, viz. *An. culicifacies* and *An. fluviatilis* were the most predominant with prevalence rate of 47.8 and 4.2 per cent respectively. The man hour density of these two species ranged between 7 to 120.2 and 0 to 11.5, respectively. The density of *An. fluviatilis* was at its peak during the post-monsoon months, which coincides with intense malaria transmission season. Results of all night mosquito landing collections on human baits showed that *An. fluviatilis* prefer to bite humans and the man biting rate was found to be 6.2 bites/man/night. *An. culicifacies* has a very low man biting rate of 0.8 bites per person per night. Mosquito blood meal analysis of these two vectors, which showed high human blood index for *An. fluviatilis* also correlate with the direct observations of all night mosquito landing collections. The sporozoite rate during high transmission season (October-December) and spring transmission season (March-April) was found to be 3.1 and 2.3 per cent, respectively. The entomological inoculation rate (EIR) was 0.48 and 0.08 infective bites per person during respective seasons. The vector species collected during low transmission season are yet to be assayed for sporozoite detection. The study showed that the tribal area is under the influence of very efficient malaria vector species and the parasite load in the community is high to maintain persistent malaria transmission. The molecular epidemiological studies were carried out at the ICGEB.

Resting behaviour of anophelines

A longitudinal study was conducted in two riverine and two streamside villages in Bisra block of Sundargarh district to know the extent of outdoor resting in relation to seasonal changes. Adult mosquito collections were made at fortnightly interval during daytime from indoor and outdoor resting places. Nine anopheline species, i.e. *An. culicifacies, An. fluviatilis, An. annularis, An. subpictus, An. vagus, An. pallidus, An. aconitus, An. splendidus* and *An. nigerrimus* were found resting outdoors in tree holes, bushes, pit shelters, under culverts, riverstream side cavities. The man hour density of all these species ranged from 0.07 to 1.9. Majority of the species were found resting outdoors in both the ecosystems but *An. culicifacies* and *An. fluviatilis* were found resting outdoors only in the forest area near river or stream. About 14 anopheline species were recorded indoors from both types of villages but the species diversity in streamside villages was more than riverside villages. However, density of anophelines was more in riverside villages than that of in streamside villages. The study showed that major proportion of anopheline species prefer to rest indoors, however, a small proportion of anopheline species do rest outdoors as well, which may be of epidemiological significance.

Susceptibility status of malaria vector species

Insecticide susceptibility tests on adult wild caught fully-fed mosquitoes of *An. culicifacies, An. fluviatilis*

and *An. annularis* were performed against DDT (4 per cent) and deltamethrin (0.05 per cent) impregnated papers as per WHO procedure. The tests revealed that *An. culicifacies* and *An. annularis* are resistant to DDT showing a mortality rate of 23 and 5.8 per cent respectively, whereas both are fully susceptible to deltamethrin. *An. fluviatilis* was found cent per cent susceptible to DDT and deltamethrin. The data have been sent to NAMP.

Mosquito blood meal analysis for host identification

During the year, 2138 blood meal samples of *An. culicifacies*, 322 of *An. fluviatilis* and 398 of *An. annularis* were assayed by gel diffusison technique to identify host preference of vector species prevalent in this area. *An. fluviatilis* was found to be having more preference for human blood rather than bovine blood (human blood index 0.65), whereas *An. culicifacies* and *An. annularis* were found to be primarily zoophagic with HBI of 0.03 and 0.02, respectively.

Gametocytocidal effect of compound 80/53

A prospective study to determine the gametocytocidal effect of the drug 80/53 in the uncomplicated *P. falciparum* malaria cases was undertaken and 18 patients with gametocytes in the peripheral blood smears were administered with the 80/53 drug @ 75 mg single dose on D-3 after chloroquine therapy. The laboratory reared unfed *An. stephensi* were subjected to membrane feeding on the heparinized blood of these patients on D-0 and D-4, i.e. before and after drug administration. The mosquitoes were dissected on D-7 and D-10 to see development of oocyst or sporozoite respectively. In D-0 blood fed mosquitoes, the sporogony was completed in seven cases only and the oocyst and sporozoite development was recorded, whereas in D-4 blood fed mosquitoes no oocyst or sporozoite was found thereby indicating that the sporogony was inhibited after administration of 80/53 drug. Further studies are in progress.

Estimation of G-6-PD deficiency, sickle-cell trait and haemoglobin in the tribal population

A total of 372 blood samples collected from different tribal communities in Sundargarh district were screened for G-6-PD deficiency by filter paper spot test. Out of these, 76 (20.4 per cent) were found deficient while 16.4 per cent population was found having sickle-cell trait. About 501 blood samples from the forest area villages and 398 from the plain area villages were tested for haemoglobin by cynomethaemoglobin method and 20.2 and 15 per cent population in the forest and plain area respectively were found having haemoglobin less than 7 g/dl and 44.5 and 18.6 per cent of the population were having Hb in the range of 7-11 g/dl in both the areas respectively. Only 35.3 per cent population in the forest area and 66.3 per cent in the plain area had normal haemoglobin above 11g/dl. Malaria may be one of the major causes of low haemoglobin.

Situation analysis under roll back malaria (RBM) initiative

Under WHO roll back malaria (RBM)) initiative, Keonjhar district has been selected. A team comprising officials from MRC HQs, Directorate of NAMP, Delhi and MRC field station, Rourkela visited Keonjhar for the malaria situational analysis. The team had extensive discussions with the district health authorities and gathered information on the structural framework of public health care delivery systems for disease

control programme with special reference to malaria, bottlenecks in malaria control operations and the role of other government departments and private sectors in malaria control activities. The team also procured available epidemiological data and other relevant information and carried out entomological surveys in one PHC area. KABP studies through questionnaire were also carried out in three PHC areas. Possibilities of linkages and partnerships with various sectors of the district for malaria control were explored.

Disease burden and economic loss due to malaria

A cross-sectional questionnaire based survey was completed in five tribal vilages of the Sundargarh district to study disease burden associated with socio-cultural aspects and economic loss due to malaria. Data analysis is in progress.

Malaria clinic

During the year 10,154 blood slides were collected from the febrile persons reported at the malaria clinic. Out of these, 1494 slides were found positive for malaria (*Pv* 585, *Pf* 888, *Pm* 3, Mixed 8). The slide positivity rate and the slide falciparum rate were 14.7 and 8.7 per cent, respectively. Out of the total malaria cases, 59.4 per cent were due to *P. falciparum.* All the positive cases, which reported directly at the malaria clinic, were given radical treatment as per NAMP drug policy.

Health education

1. On the request of ADM, Rourkela nine health camps were organised in the tribal dominated peripheral industrial area of Rourkela City where people were imparted health education regarding personal protection methods for malaria control. Six health education camps were organised in six schools in Jalda suburban area of Rourkela City.
2. The month of June was observed as "Antimalaria month" and during which different activities pertaining to health education were organised in and around Rourkela town to generate awareness among the community to fight malaria. Nine health camps were organised in different villages of Birkera and Gurundia block which are predominantly inhabited by tribals. Malaria exhibitions were also displayed during such camps. Four health awareness camps were organised in schools which were attended by about 1000 students. A students' rally through display of placards showing the mosquito/malaria control slogans was held in Tamra village under Gurundia PHC of Sundargarh district. A panchyat meeting was organised in the village Chikatmati and the members were made aware of malaria control activities.
3. In the new study villages selected for GMP-vaccine trial, 26 health education camps were organised. Malaria exhibitions were displayed to create awareness among the local tribal communities.

Training and technical support

1. Voluntary workers from 13 study villages were given training on malaria surveillance, i.e. preparation of blood slides, administration of radical treatment to malaria positive cases etc.
2. Technical guidance regarding mosquito control was given to Civil Engineering Department of Orissa Cement Ltd., Rajagangpur.

3. Epidemiological data of each PHC for the year 1988 to 1999 were collected from Ganjam and Gajapati districts in connection with studies on mapping of malaria receptive areas using remote sensing and GIS.

4. On the request of Rotary Club (Central) of Rourkela, mosquito net treatment with deltamethrin was demonstrated by MRC in a tribal village of Birkera PHC. The mosquito nets were distributed free of cost by the Rotary Club.

Participation in meetings/training courses/workshops/symposia

1. Dr. S.K. Sharma presented a paper "Malaria transmission dynamics in a tribal area of Orissa" in the V International symposium on vectors and vector-borne diseases held at Punjabi University, Patiala from 16-18 February 2000.

2. Dr. S.K. Sharma presented a paper on "Epidemiology of malaria in a tribal area of Orissa" in the XIV National Congress of Parasitology held at ICGEB, New Delhi from 23-26 April 2000.

3. Dr. S.K. Sharma and one technician from the field station undertook one week training at MRC HQs, Delhi from 19-23 June 2000 on ELISA technique for sporozoite detection.

4. Dr. S.K. Sharma participated in the review meeting of GMP-vaccine trial project held in the Department of Biotechnology, New Delhi on 12 October and presented the progress of work related to the development of field trial site in Sundargarh district.

6.9 CHENNAI (TAMIL NADU)

Chennai is endemic for malaria and contributes 50 to 70 per cent of total malaria cases recorded in the entire Tamil Nadu, mainly due to *P. vivax* and also *P. falciparum*. The contribution of falciparum malaria to the total cases is very less and has not exceeded 12 per cent during the past decade. A total of 31861 malaria cases were recorded during the year, out of which 30,931 and 930 were *P. vivax* and *P. falciparum* respectively. *An stephensi* is the only malaria vector in Chennai and it breeds profusely in overhead tanks, wells and cisterns. A total of 89,923 overhead tanks, 97,706 wells and 23,492 underground tanks are reported to be present in Chennai.

Malaria clinic

Patients from areas around the field station laboratory like Anna Nagar, Korattur, Padi, Mogappair and from far flung places attended the clinic for the diagnosis and treatment of malaria. A total of 7924 blood smears were collected and examined during the year, out of which 1319 were positive for malaria and 1235 (93.6 per cent) *P. vivax*, 81 (6.1 per cent) *P. falciparum* and three (0.2 per cent) cases with mixed infections were recorded. The SPR, SfR and *Pf* per cent were 16.64, 1.06 and 6.37, respectively.

Bednet usage by the patients attending MRC clinic

A random survey was undertaken to understand the bednet usage for the prevention of mosquito bites/ disease among the patients attending MRC clinic for the diagnosis and treatment. A total of 101 patients were interviewed on the bednet usage. The results revealed low usage of bednets (seven per cent). All the users, however, tied bed nets only during monsoon season.

Ecology of *Anopheles stephensi*

Various aspects on bioecology have been proposed to be undertaken. To start with, a preliminary survey to locate the regions of availability of variants, viz. type form, *mysorensis* and intermediate forms have been undertaken. The immatures of anophelines were collected from overhead tanks, wells cisterns and other breeding sources in various areas, namely Anna Nagar, George town, Mogappair, Red Hills, Reddipalayam, Manali, Chinmaya Nagar, Pammal, Poonamallee, Avadi, Ennore, Villiwakkam, Sundaracholavaram, Athipet, Madipakkam, Kovalam, Sriperumbudur, Sembilivaram and Pulicat area. A total of 852 overhead tanks, 566 wells, 46 cisterns and 38 other breeding sources were surveyed for the purpose. The immatures, collected were reared, emerged and the progeny developed for the identification of variants. Egg morphological studies indicated different ecological variants. The results showed that the intermediate form was present in areas such as Villiwakkam, Poonamallee, Chinmaya Nagar, G.K. Flats, Sembilivaram, Kovalam and Pammal. The *mysorensis* form was found in Pammal.

Evaluation of larvicidal efficacy of hilmilin

Evaluation of the larvicidal efficacy of hilmilin, an IGR compound, was undertaken in various habitats. Field evaluation was carried out at Vanagaram in the outskirts of Chennai City against rice field breeding anopheline and culicine mosquitoes. The larvicidal activity at 0.05 and 0.1 ppm were evaluated after a single treatment on the Day 4 after transplantation. The post-treatment immature densities were monitored

on Day 4, 7, 11, 14, 21, 26 after treatment. Water samples were also collected from the treated and untreated habitats and laboratory evaluation was made. Anophelines were more susceptible than culicines. The larvicidal efficacy of hilmilin was minimum.

Rainwater harvesting and its implication on the vector breeding

The increased demand for drinking water in the recent years has led to the popularisation of rainwater harvesting (RWH) techniques especially among the urban conglomeration. Though open space for conservation is lacking, rainwater by and large is harvested as ground water in urban areas. In Chennai, Metrowater, Alacrity foundation etc. are involved in rainwater harvesting and various techniques are adopted. Anna Nagar and adjacent areas in Chennai City have been selected to study the implications of RWH on mosquito breeding. A total of 11 flats where RWH is practised, have been identified. Preliminary surveys have been undertaken in flats to enumerate breeding sources and mosquito breeding. Rainwater harvesting by percolation pits, well-cum-canal-cum percolating pit, service well-cum-rechargeable well and borewell methods are followed. The systems were checked for mosquito breeding and no breeding was observed.

Larvivorous fishes in Chennai

Larvivorous fishes were collected from ponds, lakes, paddy fields etc. in the outskirts of Chennai City. The species identified were *Oreochromis mossambica, Oryzias carnaticus, Rasbora daniconius, Macropodus cupanus, Puntius vittatus, Aplocheilus blockii, Aplocheilus lineatus, Aplocheilus parvus, Colisa fasciata, Chanda ranga* and *Channa punctatus*. Further studies on the larvivorous potential are in progress.

Health education

Health education and training programmes were organised for students during the year. Health education programmes included lectures, live demonstrations, exhibitions, video shows etc. on malaria and its control. Emphasis was given to bioenvironmental control methods. The importance of mosquito proofing of overhead tanks, wells and cisterns was highlighted. In the training programmes, in addition to the above the participants/ students were trained on blood smear preparation, staining methods and identification of different stages of parasites. Ten programmes were organized in schools and colleges, one for NGO and three for governmental organizations.

An exhibition on the theme 'Malaria control — Everyone's concern' was organised from 26-30 June at the field station premises. Dr. Anbumani, Member, Governing Council of ICMR inaugurated the exhibition. Dr. J. Radhakrishnan, Commissioner Chennai Corporation, Dr. L. Dhanaraj, Regional Director, ROH & FW, Government of India, Dr. P.K. Srivastava, Deputy Director, NAMP, Mr. C. Rajendran, Chief Entomologist, DPH & PH were the other distinguished guests. About 795 students from 11 different schools, colleges, local residents and officials from other health/educational departments visited the exhibition. Exhibits included life-cycle charts of malaria parasites, epidemiological profile of Chennai, Tamil Nadu, India and global picture, detection of malaria parasites with conventional microscope and QBC method. Besides photographs of anopheline and culicine breeding sources, breeding sources or account of engineering defects, model houses with mosquitogenic conditions created due to improper construction

of OHTs, wells and sumps along with an ideal house with properly covered standard designed lids were displayed. Live displays included both immature and adult mosquitoes, larvivorous fishes and other aquatic predators of mosquito larvae. Video shows on malaria and its control were also shown.

M.Sc. student's projects

Two students from Prince Venkateswara College for Arts and Science, Chennai were guided in M.Sc. project work. The two studies were "Evaluation of larvicidal efficacy of extracts from the plant, *Calotropis gigantea* — A preliminary study" and "Study on the gut microflora of *An. stephensi* breeding in overhead tanks". The studies were conducted in Anna Nagar and Mogappair area. A total of seven bacterial and six fungal genera were isolated. The bacterial genera included *Bacillus, Pseudomonas, Klebsiella, Escherichia, Flavobacterium, Proteus* and *Serratia*. *Aspergillus, Mucor, Penicillium, Rhizopus, Fusarium* and *Yeast* were the fungal genera observed.

Meetings/Seminars/Trainings attended

1. Alex Eapen attended a meeting on GIS based malaria surveillance in Tuticorin at the Office of the Director, DPH & PM (Malaria & Filaria), Chennai in January.

2. Alex Eapen and K. John Ravindran attended National Symposium on Recent Trends in Combating Mosquitoes in Chennai in October and presented papers on "Larvivorous fishes in mosquito control" and "Riceland mosquitoes and their control", respectively.

3. Alex Eapen attended a meeting on Urban malaria problem in Tuticorin, in October.

4. Alex Eapen delivered a talk on "IEC activities for mosquito proofing of overhead tanks, wells and cisterns in Chennai".

5. Alex Eapen delivered a talk on "Antimalaria activities in Mogappair and Padi area, Chennai" in November.

6. Alex Eapen delivered a talk on "Bioecology of *An. stephensi*", Chennai in December.

7. K. John Ravindran participated in WHO sponsored programme on "Pretesting of training module on comprehensive vector control" at Hosur in November and December.

6.10 SHAHJAHANPUR (UTTAR PRADESH)

Geographical reconnaissance

GR imparts a great role in the bioenvironmental control strategy. It helps in finding out the actual breeding spectrum of mosquitoes and accordingly proper control strategies may be taken. GR for mapping of mosquito breeding sites was carried out in urban areas of Shahjahanpur. Various types of mosquito breeding sites recorded during the survey were four ponds/pools, 77 pits/ditches, 691 drains, 17 wells, 221 hand pumps, 799 overhead tanks, 459 tanks, 308 coolers, five stagnant water collections on the street, nine nallahs and 232 tyre collections and old pitchers.

Approximate area of above breeding sites was recorded as 85,397 m^2. The per cent larval positivity was found highest in ponds/pools (100 per cent), followed by nallahs (66.7 per cent), wells (64.7 per cent), pits/ditches (50.6 per cent), drains (46.3 per cent), tyre collections and old pitchers (37.5 per cent), tanks (19.8 per cent), coolers (14.9 per cent), overhead tanks (12.1 per cent), hand pump/pits (nine per cent). No larvae were found in roadside stagnant water collections. Detail maps of various breeding sites were also prepared. Results of one-year survey revealed high mosquitogenic conditions in the area.

Entomological study

Density of adult mosquitoes was monitored in Paintapur and Saijna villages of Dadraul PHC of District Shahjahanpur. The man hour densities of anophelines, culicines, *An. culicifacies* and total mosquitoes varied from 3 to 96, 13 to 182, 10 to 260 and 18 to 214, respectively.

Parasitological surveys

Malaria: Blood smears of patients with active fever who visited the malaria clinic at the field station were examined. A total of 87 blood smears were examined. All were found negative.

Filariasis: Blood smears of patients with suspected filariasis who attended the clinic of the field station were prepared, stained and examined for microfilariae. A total of 53 blood smears were examined. Out of these, two smears were found positive for microfilariae. The overall *mf* rate was 3.8 per cent.

Survey of proposed site for thermal power station

Malariogenic potential of four villages, namely Dilawerpur, Pasiyani, Gwari and Chandera covering a population of 3375 around proposed site for thermal power station, Roza, Shahjahanpur was studied. The surveys of mosquito breeding places in all the villages was carried out of which revealed a wide variety of mosquito breeding places in and around the villages such as 121 ponds, 415 pits/ditches, 317 drains, 198 hand pump pits, 440 wells and 11 river sites. Approximate area of above breeding sites recorded was 24179 m^2. The per cent larval positivity was found highest in river (100 per cent), followed by pits/ ditches (39 per cent), ponds (34.7 per cent), drains (30.9 per cent), hand pumps (27.8 per cent) and wells (27.5 per cent). The survey revealed high mosquitogenic conditions in the area. A total of 184 blood smears of fever cases were collected during the surveys and all were negative for malaria parasite.

Field trial of biocides

Field trials of biocide *Bacillus thuringiensis* received from M/s. Wockhardt, Mumbai has been initiated in the villages of Dadraul PHC of District Shahjahanpur. The survey of mosquito breeding places of the villages was carried out which revealed a wide variety of mosquito breeding places in and around the villages. Adult mosquitoes were captured by hand collection to obtain the baseline entomological data. Blood smears of fever cases were also prepared to obtain the data related to malaria. After obtaining baseline data, biocide was applied at a dose of 0.5 gm/m^2 in the river bed pools. Regular monitoring of larval densities was carried out for the impact assessment. Biocide proved to be highly effective against III and IV instar anopheline and culicine larvae. Anopheline larval density per dip before application (Day 0) was 9.1 which declined to 0.7 on Day 1. Culicine density per dip before application was five. which declined to 0.5 on Day 1. No mortality of larvae was recorded in control habitats. Further studies are in progress.

Mosquito net usage survey

Survey on the users of mosquito nets was carried out in urban localities of District Shahjahanpur. Out of 98 persons surveyed, most of the persons were using mosquito nets occasionally for the purpose of protection from mosquito nuisance and to prevent malaria and other vector borne diseases. Except one, none were aware of the insecticide treated mosquito nets. Further survey is in progress.

6.11 SHANKARGARH (UTTAR PRADESH)

Among all the PHC's of District Allahabad, Shankargarh PHC which is situated at a distance of about 45 km southwest of Allahabad City, is well-known for stone/silica sand quarries. Topographically the area is plain with rocky hills, patchy forests, rivers and streams. The climate is hot and the area is drought prone during summers, while the monsoon causes near flooding of streams, ponds and quarries. The area records a high incidence of malaria and especially *P. falciparum* cases. Innumerable breeding sites coupled with large-scale labour movement, asymptomatic carriers and drug-resistant *P. falciparum* has further aggravated the situation. During the year 2000 the following activities were carried out at the field station.

Passive surveillance

A malaria clinic has been functioning at the PHC campus since 1992. The clinic covers the local population as well as the neighbouring villages. Blood slides are examined and radical treatment is given to malaria positive cases. The data show a distinct cycle of *Pv* and *Pf* cases. The maximum number of *Pv* cases were detected during the months of May and June, while the maximum number of *Pf* cases were detected during the months of October to December. Out of a total of 4574 blood slides examined during the year, 534 were found positive for malaria parasites, the SPR being 11.7 per cent and SfR 1.5 per cent. compared to malaria incidence during the year 1999, there was a decline in 2000 (SPR: 11.7 per cent in 1999 compared to 30.6 per cent in 2000). The parasite rates in infants was 10.3 per cent (6/58) and in children of 1-10 years, it was 13.1 per cent (14/106).

Active surveillance of malaria in stone quarries

The problem of malaria in the area is mainly due to the presence of stone/silica sand quarries where large-scale labour movement is witnessed every year. During the year, weekly surveillance was carried out covering a population of 2877. From the monthwise data, out of a total of 131 blood smears examined 37 were found positive for malaria infection, the SPR being 28.2 per cent, while SfR was 5.3 per cent. Only two blood slides of infants were prepared, which were negative. Among 65 blood slides of children in the age group of 1-10 years, 18 were found positive. The CPR was 27.7 per cent. The data show that the incidence of malaria is almost double when compared to town area. The highest SPR was recorded during the month of January.

Drug-resistance study in Daltonganj District Palamu

A joint team from Delhi and Shankargarh field station visited Daltenganj, Bihar to study the chloroquine sensitivity status in the local population. Out of 763 blood smears examined, 202 were found positive for malaria parasites (173 *Pf* and 29 *Pv*). Out of 35 cases of *Pf* included in the study, 14 were found resistant to chloroquine, while in case of *Pv* all the 20 cases responded to chloroquine.

Conferences/ meetings attended

1. Dr. B. Shahi and Dr. A. Gupta presented papers at the 1st National conference on recent trends in life management at Bipin Behari College, Jhansi, in October 2000.
2. Dr. B. Shahi presented a paper at the LXX Symposium of the National Academy of Sciences, Allahabad, in November 2000.
3. Dr. B. Shahi and A. Gupta had quarterly meetings at the Regional-Malaria Office, Allahabad, regarding district malaria situation and Kumbh mela survey.

6.12 CAR NICOBAR (A&N ISLANDS)

Bioenvironmental control of malaria

Malaria was a serious problem in Car Nicobar Island. Malaria API was 194 in the year 1989. After implementation of bioenvironmental control strategy, there has been a decline in the malaria incidence. During the year 2000, 262 malaria cases were recorded with an API of 9.5. Bioenvironmental interventions are now in progress in all the villages of Car Nicobar Island. *Gambusia affinis* were released in large numbers into the mosquito breeding habitats such as marshy, creek, mangrove and low-lying areas of the Island to control the mosquito breeding. Maintenance and operation of one way sluice gate in Teetop and Sawai creek has considerably reduced the breeding of *An. sundaicus* to a low level. During this year large-scale production of *Gambusia* was achieved in Nicobar Island. There are 14 established hatcheries of *Gambusia* in Nicobar Island, of which eight hatcheries are situated in Car Nicobar Island. An estimated stock of three million fish is available in Nicobar Island. *Ophlicara aporos* fish was released in the wells for the control of *An. sundaicus* breeding. On demand by the Deputy Director Malaria and District Malaria Officer, NAMP (Andaman and Nicobar Islands), 10,000 *Gambusia* were supplied to Teressa Island. About 4000 *Gambusia* were supplied to local air force station. *Gambusia* hatcheries were established at Katchal, Chowra, Nancowry and Campbell Bay Islands. In addition, in the Jhanseen village of Katchal Island, *Oryzias melastigma* hatcheries were established. In the remote Chowra Island *Gambusia* fish were released into the Syntex tanks for the control of mosquito breeding.

Malaria transmission dynamics in creek and non-creek areas of Car Nicobar

A study on ecology and the role of *An. sundaicus* in malaria transmission was started in seven creek and nine non-creek areas of Car Nicobar. The density of *An. sundaicus* based on fortnightly hand collections from January to December 2000 ranged from 17.3 to 51.6 and 0 to 1.33, respectively in the above areas. The densities were higher in creek area. It has been observed that *An. sundaicus* shows dimorphism in its breeding habitat. It prefers to breed in brackish water, creeks, marshy areas, mangrove cuttings, pools infested with putrifying masses or algae. In fresh water, it breeds in cement tanks, ponds, wells and marshy areas. From the mosquitoes emerged from the larvae collected from creek area, 72 per cent mosquitoes comprised of *An. sundaicus;* in non-creek area this proportion was 28 per cent. In the former area a substantial number of this species rested outdoors. Outdoor resting habitats were *keori* bush, coconut stumps, and dry coconut leaves. Indoor habitats were *copra machan* and cattlesheds. In non-creek area occasionally the species rested in cattlesheds too. The feeding behaviour of *An. sundaicus* (fresh water and brackish water) population was studied by blood meal analysis. Results showed zoophagic nature of the species at different resting sites. In both the areas *An. sundaicus* fed on pig, cattle and humans.

The indoor man biting of *An. sundaicus* was significantly higher than that of outdoors. The species showed bimodal biting activity with the first peak at midnight and the second at 1400 hrs. The sporozoite rate was 0.001 per cent in creek area and no specimen was incriminated in non-creek area. The cytogenetic characterization showed only cytotype D in both fresh water as well as in brackish water areas.

During the year, a total of 262 (*Pv* 92; *Pf* 170) positive malaria cases were detected from creek and non-creek areas of Car Nicobar. From creek area 83 cases and from non-creek area 179 cases were detected. Many migratory labourers from Orissa, Bihar and Tamil Nadu work in creek and non-creek

areas. In creek area seven malaria cases were detected from migratory labourers. Sixty cases were detected from the migratory labourers residing in the non-creek areas. Further study is in progress.

Ecology of *An. philippinensis*

The study was carried out in the forest area of Hutbay Island (Little Andaman). Streams, fresh water channels, ponds, seepages from dams, and rice fields with algal growth were the major breeding sites of *An. philippinensis*. Breeding was observed in association with vegetation specially algae, cara and spirogyra. It was observed that salinity prevents its breeding. It did not breed in creeks and mangrove areas, and in association with green lemna species. In all the habitats it composed of more than 50 per cent of all anophelines. The man hour density of *An. philippinensis* in indoor collection was nine. The man hour density in the dense forest area was 35 on the cattle bait. It was observed that during the whole night collection in the dense forest area, the species was highly zoophagic. Main biting period was from 1730-2330 hrs with a peak biting on humans at 1830 hrs. On cattle, main biting occurred from 1730-0130 hrs with a peak at 2030 hrs. In Andaman group of Islands, the man hour density of *An. philippinensis* was 11.5 in Diglipur, 147 in Mayabunder, 17.1 in Betapur, 12.7 in Rangat, and 54.6 in Hutbay. About 361 *An. philippinensis* and 86 *An. sundaicus* collected from indoors were incriminated for sporozoites. None was found positive. 321 blood meal samples of *An. philippinensis* were collected to study the anthropophilic index.

Mosquito fauna of Great Nicobar, Hutbay and Teressa Islands

So far 20 species belonging to five genera, viz. *Anopheles, Aedes, Armigeres, Culex* and *Mansonia* were identified. The most prevalent genus was *Anopheles* which consisted of eight species, viz. *An. sundaicus, An. barbirostris, An. barbumbrosus, An. kochi, An. roperi, An. vagus, An. insulaeflorum* and *An. tessellatus*. *An. sundaicus* was the predominant species. The mosquito fauna of Hutbay (Little Andaman) Island was studied. So far, 16 species belonging to five genera have been recorded. The most prevalent genera was again the *Anopheles* with 11 species, i.e. *Anopheles aconitus, An. aitkenii, An. barbirostris, An. balabacensis, An. barbumbrosus, An. philippinensis, An. sundaicus, An. roperi, An. insulaeflorum, An. vagus* and *An. sinensis.* In Teressa Island the species recorded were: *Anopheles tessellatus, An. barbirostris, An. barbumbrosus, An. kochi, An. insulaeflorum* and *An. sundaicus. An. tessellatus* was the predominant species and its role in the malaria transmission is being studied.

Insecticide susceptibility studies

In Andaman and Nicobar Island *An. sundaicus* species was susceptible to DDT (four per cent), malathion (five per cent), lambdacyhalothrin (0.05 per cent), deltamethrin (0.05 per cent) and propoxure (one per cent) and dieldrin (0.04 per cent).

Cytotaxonomic identification

Cytological examination revealed that in Sippighat (Port Blair, South Andaman) karyotypes of both *An. philippinensis* and *An. nivipes* were found and were sympatric. In Middle Andaman (Betapur and Bangat) only *An. philippinensis* was found. In Little Andaman (Hutbay) all the specimens examined were of *An. philippinensis*. Cytological examination of more samples from these Islands is in progress.

Malaria clinic

A total of 1232 blood smears were collected and examined during the year, of which 236 were positive for malaria. The number of *Pf* and *Pv* cases recorded were 146 and 90 respectively. The SPR and SfR were 19.1 and 11.6 per cent, respectively. Results were provided promptly to local air force and civil hospital medical authorities for further treatment of cases.

Filariasis survey

A filariasis survey (day and night) was carried out at Car Nicobar Island among the Nicobaries and mainlanders. Out of a total of 1025 slides examined, 100 (9.75 per cent) were found *mf* positive. Two distinct forms of *Wuchareria bancrofti,* i.e. nocturnally periodic form and diurnally sub-periodic form were found in the Nicobaries and mainlanders, respectively. *Cx. quinquefasciatus* was incriminated as the vector for transmitting both the forms. It is for the first time that *Cx.. quinquefasciatus* was incriminated as the vector of diurnally subperiodic forms of *W. bancrofti*.

Survey on mosquito net usage

A questionnaire based survey about the uses and opinion about mosquito nets was carried out at Car Nicobar Island. The study revealed that of the total net usages, 55.4 per cent of nets were used by Nicobaries. In creek area, 64.6 per cent nets were used by the villagers and in non-creek area 51.6 per cent nets were used by the villagers. The villagers were interested to get the mosquito nets free or at a subsidized rate from the government. There is a demand from the tribals to receive insecticide treated nets. Based on the increasing demand from the Tribal Council for the use of impregnated bednets, 450 mosquito nets were treated with cyfluthrin @ 50 mg/m^2 and distributed among the tribals.

Mosquito cultures at the field station

At the field station wild strain (fresh water form and brackish water form) of *An. sundaicus* is being reared. There are 12 morphological mutant forms. Besides, three strains of *An. sundaicus* (Nancowry, Katchal and Teressa), wild strain of *Cx. quinquefasciatus, Aedes aegypti*, *Ae. albopictus* and *Toxorhynchites splendens* are also being maintained.

Health education activities

The antimalaria month was observed under the chairmanship of Deputy Commissioner, Car Nicobar. A meeting was held in civil hospital. All village captains and the tribal council members attended the meeting. Malaria exhibition was also put up. Malaria demonstration camps were organized in eight villages to generate awareness. About 146 group meetings and video shows on malaria control were organized in the villages of Car Nicobar. An exhibition for Nicobaries of Kimious village was organized wherein neem oil as repellent was distributed. Another exhibition for air force and naval staff was also organized.

Trainings

1. Dr. M.K. Das was invited as a resource person and speaker on bioenvironmental method of control of malaria in a 5-day orientation training programme on malariology for PHC Medical Officers of A & N Islands organized by NAMP Port Blair from 15-20 March 2000.

2. Group Captain M.K. Mishra, Joint Director Medical Service (Health), Air HQs., New Delhi visited the field station and discussed about the malaria situation at Car Nicobar Island and the latest development in the rapid diagnostic kits for malaria and filaria.

7. PRESENT MANDATE OF THE FIELD STATIONS

The Executive Committee of the IDVC project in its meeting held from 10-12 June 1999 suggested following future mandate for each field station in addition to trainings, workshops and transfer of technology activities.

Nadiad (Gujarat)

- *Health impact assessment (HIA) of projects and project malaria*: Immediate objective would be to work in the command area of the Sardar Sarovar dam project. Project malaria would relate to urban, industrial, ports and irrigation projects.
- Epidemic forecasting and generation of database for the validation of mathematical moduling.
- Socio-economic issues related to sustainability of insecticide treated mosquito nets.
- Human toxicity studies in collaboration with NIOH on new insecticides introduced (pyrethroids etc.).
- Field evaluation, of new insecticides and monitoring and mapping of insecticide resistance.
- Basic research work on mosquito pathogenic fungi and bacteria.

Jabalpur (Madhya Pradesh)

- The set-up of the field station should be developed for malaria vaccine trials and trials with new drugs and drug combinations.
- The work on malaria in pregnancy should be expanded with strategies to prevent abortions and other ill-effects of malaria particularly on the infants and pregnant women. A common protocol should be developed in consultation with Delhi staff for use at other field stations.
- Project malaria and migration pattern should be studied to understand the changing malaria transmission dynamics in the tribal populations.
- At the Indira Sagar dam site, pre- and post-construction surveys may be conducted to assess the malariogenic potential.
- Sociological studies on the tribal populations related to insecticide treated mosquito nets since it is an important intervention in tribal districts. Studies should be taken up to encourage the use of bednets and their proper maintenance for ensuring sustainability.
- Training of health staff on various interventions measures.

Hardwar (Uttaranchal)

- Determination of insecticide residues, resistance to antimalarials and relationship to the evolution of resistance in the vectors and the parasites.
- Isolation of new molecules having insecticidal, or repellent action and antimalarial properties.
- Monitoring of residues on the insecticide treated mosquito nets.

- Quality control (chemical analysis) of insecticides, antimalarials etc. used in NAMP.
- Monitoring of resistance in parasites particularly *P. vivax* to antimalarial drugs.
- Contract research on industrial malaria control.

Panaji (Goa)

- *Search for new biological control agents*: Isolation, characterization and identification of fungal and bacterial agents.
- Development of seasonal habitat specific vector control strategies for small and medium towns of Goa, India.
- Forecasting of malaria outbreaks in Goa and alerting the state NAMP for prompt response.
- *Malaria education in schools:* Development and introduction of comprehensive module for IEC programme on malaria in schools through NCERT.
- Training, consultancy and advocacy of malaria control in urban areas of Goa.
- Investigations into malaria problem in Goa in relation to construction activities and population immigration including socio-economic aspects and the impact on tourism in collaboration with Department of Sociology, Goa University.
- Testing of emerging technologies for the NAMP and the impact assessment on vector and transmission of malaria in urban areas (Biological/Chemical control of vectors; Diagnostic tools).

Bangalore (Karnataka)

Bioenvironmental methods for malaria control have successfully controlled malaria in three PHCs. This work should be expanded to cover the entire Karnataka (rural) state. This would require networking with various institutions in Karnataka, involvement of the NGOs and close interaction with the state health department. Technology transfer through training workshops, documentation of the experience in the implementation of the bioenvironmental malaria control, and devise strategies to sustain the impact on malaria control. This work should be supported by :

- Stratification of Karnataka based on *An. culicifacies* and *An. fluviatilis* sibling species prevalence.
- Analysis of physico-chemical nature of breeding habitats of vectors of malaria in Karnataka especially with reference to sibling species. Staff training is recommended on the sibling species identification and the health impact assessment.
- Epidemiological surveys to be carried out in Mangalore City to establish the cause of the spread of malaria, and geographical reconnaissance to suggest interventions. MRC field station would take up advisory and consultancy role and the field operations would be carried out by the Corporation, Health Department of Karnataka and NGOs.

- Training workshops for the state programme officers and their staff.

Sonapur (Assam)

- Investigations of malaria epidemics and development of early warning system.
- Study the biology of malaria vector in north-eastern states with particular emphasis on the use of ITMNs as a major intervention strategy; study socio-economic factors; techniques to encourage the use of ITMNs; methods of maintenance and how to increase sustainability of ITMNs. Link-up with NAMP on the research needs and priority in the ITMNs.
- Encourage larvivorous fish, wherever feasible.
- Training of health staff on ITMNs and other methods as may be required from time-to-time.
- Monitoring drug and vector resistance.

Haldwani (Uttaranchal)

- Transmission dynamics of forest malaria in deep forest, deforested and afforested areas in District Nainital in order to develop suitable control strategies.
- Stratification of District Nainital for malaria control measures.
- This field station is to be developed as a training centre for the malariology and malaria entomology courses.

Rourkela (Orissa)

- Application of ITMNs in a tribal district, particularly to study the sociological and economical factors that may affect the implementation of ITMNs.
- To study the distribution and the role of *An. culicifacies* and *An. fluviatilis* species complexes in the transmission of malaria.
- *Malaria in pregnancy*: This study should be taken up on the basis of a common protocol to be developed jointly with the Jabalpur field station and MRC HQs, in Delhi.
- The committee felt that rural areas of Rourkela provide a unique opportunity to test drugs and vaccines.

Chennai (Tamil Nadu)

- Cost-effectiveness analysis and acceptability of appropriate methods of mosquito proofing of overhead tanks and wells in Chennai and study impact of mosquito proofing on malaria control in Chennai.

- *Rain water harvesting technique* : Implications on vector breeding potential and methods to mitigate vector breeding.

- Health impact assessment in areas under high intensive development projects.

- Studies on persistence of malaria transmission in Chennai.

- Bioecology of *An. stephensi*.

- Training of health staff.

Shahjahanpur (Uttar Pradesh)

Control of rural malaria was successfully demonstrated by the bioenvironmental methods. Due to unstable nature of malaria in this district, malaria is at the lowest ebb and there are now new challenges to be addressed. The progress of the work in the last few years has not been satisfactory. The field station could work on the following:

- Monitoring of filariasis and chemotherapy using DEC and Ivermectin.

- *Biological control*: Maintenance and distribution of larvivorous fish.

Shankargarh (Uttar Pradesh)

Only malaria clinic is being run, and occasionally whenever the state health department requires help, the field station has been providing the same. The progress of the work presented was not satisfactory. Keeping in view the staff structure, following study is recommended:

- *Migration malaria*: Monitoring of population movement and malaria incidence.

Car Nicobar (A& N Islands)

The field station has successfully demonstrated malaria control by bioenvironmental methods. Following studies are recommended:

- Role of *An. philippinensis/An. sundaicus* in the transmission malaria in Hutbay Island.
- Release of larvivorous fish *Gambusia affinis* in Car Nicohar and other group of Islands. The field station has achieved its objective by demonstrating malaria control by bioenvironmental methods and it has been working in close association with local authorities. It is now time for the local authorities to take over.
- Epidemiological investigations on malaria in creek and non-creak areas of Car Nicobar Island.
- Cytotaxonomic identification of members of the *An. philippinensis– nivipes and An. sundaicus* complexes in Andaman and Nicobar group of Islands.

8. AWARDS AND INTERNATIONAL FELLOWSHIPS/ MEETINGS

1. Dr. Neeru Singh, Deputy Director, MRC, Jabalpur received the ICMR award for biomedical research in under developed areas.

2. Dr. Ashwani Kumar, Senior Research Officer, MRC, Panaji visited London School of Hygiene and Tropical Medicine, U.K. under bilateral exchange programme between INSA and the Royal Society, UK and conducted research in the laboratory of Prof. Chris Curtis.

3. Dr. R.M. Bhatt, Senior Research Officer, MRC, Nadiad visited London School of Hygiene and Tropical Medicine, U.K. and underwent training in Entomology and GIS from 14 February-15 May 2000.

4. Dr. R.S. Yadav, Asstt. Director, was invited to participate in the USAID-Environmental Health Programme sponsored Inter-country Workshop on Cross Border Issue in Malaria, Kala-azar and J.E. Prevention and Control at Hetauda, Nepal from 24-28 July, 2000 and presented a technical overview on "Malaria Surveillance Systems and Laboratory Diagnosis in India"

5. Dr. S.K. Ghosh, Asstt. Director, participated in the USAID-Environmental Health Programme sponsored Inter-country Workshop on Cross Border Issue in Malaria, Kala-azar and J.E. Prevention and Control at Hetauda, Nepal from 24-28 July, 2000

6. Dr. V.K. Dua, Deputy Director, visited Department of Pharmacology and Therapeutics, Asthon Street Medical School, University of Liverpool, UK on 6-month Wellcome Trust Travel Grant Fellowship.

9. PAPERS PUBLISHED/PRESENTED

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